Electrical Engineering

August
1931

Pacific Coast Convention — Lake Tahoe, California — August 25-28, 1931

Published by
American Institute
of Electrical Engineers, New York

FUTURE MEETINGS

of the

American Institute of Electrical Engineers

Place	*Dates*	*Nature*	*Latest Date for Receipt of Manuscripts*
Lake Tahoe, Calif.	Aug. 25-28, 1931	Pacific Coast Convention	(Closed)
Kansas City, Mo.	Oct. 22-24, 1931	District Meeting	(Closed)
New York, N. Y.	Jan. 25-29, 1932	Winter Convention	Oct. 26, 1931
Milwaukee, Wis.	March 14-16, 1932	District Meeting	Dec. 14, 1931
Providence, R. I.	May - 1932	District Meeting	Feb. - 1932
Cleveland, Ohio	June 20-24, 1932	Summer Convention	March 20, 1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that their papers may be docketed for consideration by the Meetings and Papers Committee, as programs for all meetings are formulated several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author information in regard to the Institute's rules relating to the preparation of manuscript and illustrations.

MEETINGS OF OTHER SOCIETIES

SOCIETY OF AUTOMOTIVE ENGINEERS, Hotel Statler, Cleveland, Ohio, September 1-3, 1931. (Dr. G. W. Lewis, Director of Aeronautical Research, National Advisory Committee for Aeronautics, Washington, D. C.)

INTERNATIONAL ILLUMINATION CONGRESS 1931, London, Glasgow, Edinburgh, Sheffield and Buxton, Birmingham, and Cambridge, September 1-19, 1931. (Honorary General Secretary, International Illumination Congress, 32 Victoria Street, London, S. W. I., England.)

ROCKY MOUNTAIN DIVISION N. E. L. A., annual convention, Stanley Hotel, Estes Park, Colo., September 2-4, 1931. (G. E. Lewis, 367 Gas & Electric Building, Denver, Colo.)

ELECTROCHEMICAL SOCIETY, Hotel Utah, Salt Lake City, Utah, September 2-5, 1931. (C. G. Fink, Columbia University, New York, N. Y.)

NEW INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS, 1st International Congress, Zurich, Switzerland, September 6-12, 1931. (Prof. M. Ros, Dr. h. c., 27 Leonhardstrasse, Zurich, Switzerland.)

AMERICAN WELDING SOCIETY, Copley-Plaza Hotel, Boston, Mass., September 21-25, 1931. (M. M. Kelly, 33 West Thirty-Ninth Street, New York, N. Y.)

ILLUMINATING ENGINEERING SOCIETY, William Penn Hotel, Pittsburgh, Pa., October 13-16, 1931. (E. H. Hobbie, 29 West Thirty-Ninth Street, New York, N. Y.)

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th Street, New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 50
No. 8

The JOURNAL of the A.I.E.E. for August 1931

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ENTERED as second class matter at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

STATEMENTS and opinions given in articles appearing in Electrical Engineering are the expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on all controversial matters.

Electrical Engineering is indexed in Industrial Arts Index.

Printed in the United States of America. Number of copies this issue—

24,000

This Month—

Front Cover

Emerald Bay—Lake Tahoe, California—where Pacific Coast conventioneers may spend pleasant hours between technical sessions.

—— Turn to Next Page

SWASEY gifts to The Engineering Foundation now total three-quarters of a million. *(See p. 689.)*

KANSAS CITY, host city to the Institute's fall meeting, offers the Kansas City Athletic Club as headquarters. *(See p. 679.)*

BOARD of directors sanctions Montana Section and considers other important questions at summer convention meeting. *(See p. 684.)*

DELEGATES attending the summer convention recommended that the board of directors provide for national and Section membership transfer committees. *(See p. 679.)*

TRENDS in the practise of power-system grounding based upon recent A. I. E. E. committee reports show a definite shift toward solid grounding. *(See pp. 638-41.)*

NEON lighting and other developments in luminescent gaseous tubes are reviewed historically and technically in two articles written by authorities on the subject. *(See pp. 648-52.)*

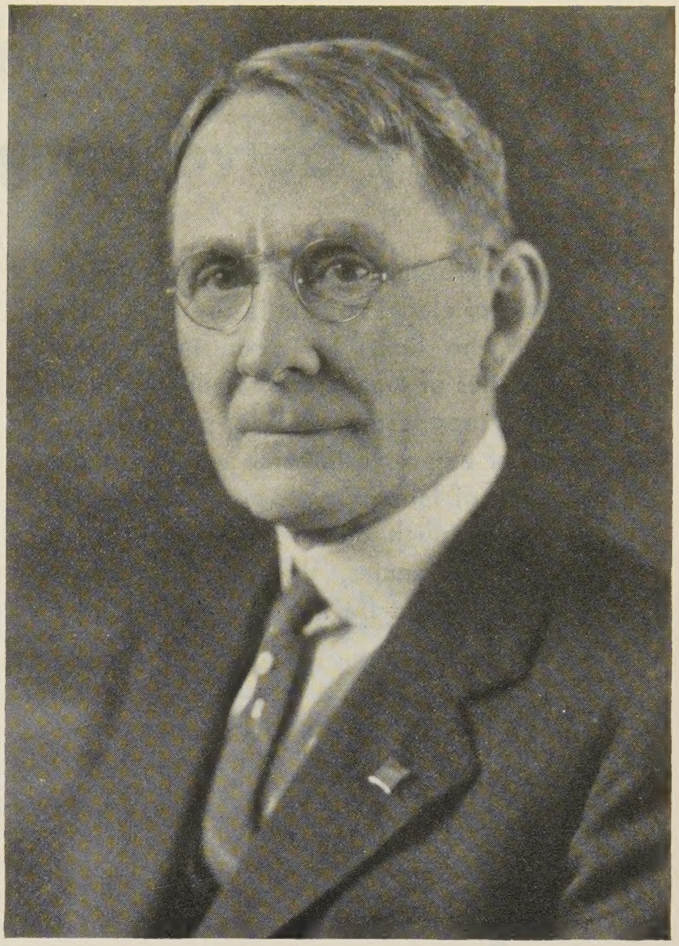
BURN-OFF characteristics of a-c. low-voltage network cables, exhaustively investigated through a series of field tests staged by a New York utility, are reviewed comprehensively in this issue. *(See pp. 662-4.)*

INSULATION research as reflected in recent Institute papers is reviewed in this issue *(see pp. 672-7)*. Discussion offered at the recent summer convention reveals a decided difference of opinion as to the practicality of certain decisions reached through laboratory research. *(See pp. 683-4.)*

BENEFITS to civilization accruing from scientific and engineering advances are to be considered by eminent persons as a part of an ambitious publication program undertaken by The Engineering Foundation. *(See p. 689.)* The first of the proposed series of articles appears in this issue of Electrical Engineering *(see pp. 641-4)*; the editors will welcome comments, criticisms, and/or rebuttal.

Doctor Skinner Takes the Helm

For the first time in his more than forty years of aggressive leadership in the electrical industry the Institute's new president takes a position vacated by another. Always he has pioneered, developing new processes, new departments, new products, new refinements; now he assumes leadership of the Institute. It is confidently to be expected that Doctor Skinner's pioneer spirit, keen foresight, and indomitable courage will prove invaluable to the Institute. His brief message follows.



Charles Edward Skinner

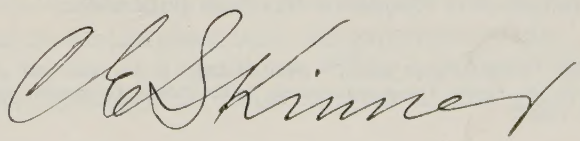
A. I. E. E. president 1931-32

FORWARD is the vital watchword, now as never before! We now are emerging from what perhaps is the most far reaching of the cyclic economic disturbances that have occurred during my forty-odd years of active service in the electrical industry. Far from being downcast, however, I have supreme confidence that we are at the beginning of an era even more significant in its possible advances than any that has gone before.

We are electrifying every industry. We may assume that the railroads are looking to electrification as one means of retaining transportation supremacy. Of profound significance is the fact that by far the most comprehensive railway electrification is being undertaken through a coordinated plan participated in by all parties at interest, including manufacturers and operators. Domestic application of electrical devices is only well begun and the next decade undoubtedly will see tremendous advances in this direction, releasing the household and farmstead from many drudgeries of the past and present. Thus, sketchily, we note that the electrical engineer is taking an ever increasingly important place in the affairs of the nation.

In all of this it is evident that the American Institute of Electrical Engineers has both a great responsibility and a great privilege to serve with increasing effectiveness its more than 18,000 members. To do this with a membership that is as diversified in its interests as it is far flung geographically, the Institute must go forward fearlessly, revising its policy and procedure as required to enable the best possible service to each individual member and each technical interest. Meetings must be arranged better to serve both the local and national interests of Branches, Sections, and Districts; publications must be developed to give to the specialist his detailed information and to the membership as a whole an accurate reflection of contemporary advances in the art and science of electrical engineering; members must be encouraged to participate more generously in Institute affairs; committees must be on the alert to develop their special fields. Progress in these directions already has been made; efforts under way must be pushed. However, in the final analysis, it is only through the loyal aid and wholehearted support of each individual member that real success can be achieved.

As for myself, I pledge my best efforts toward the advancement of the Institute in its many interests, and to uphold the best traditions of my illustrious predecessors. It is with confidence in the members of the Institute, confidence in the future of our industry, and confidence in the faith that the American Institute of Electrical Engineers can and will serve this industry ever more effectively, that I begin my term as its president.



Will Tuned Power Lines Eventually Solve Long Distance Transmission?

A new approach to an important problem in the field of electric power is offered by the author, who limits his discussion to the possibilities of tuned lines rather than their practical application. He presents the results of extensive research work, and on the basis of laboratory experiments points out that through the use of higher transmission frequencies, the efficiency of a given line might be increased as much as 500 per cent.

By
H. H. SKILLING
Associate A. I. E. E.
Stanford University, California

LESS THAN 50 years ago when electrical engineering was young, there was vital and active interest in subjects which today are taken literally for granted. In early electric power work not the least of these was the question of choosing a desirable frequency for a-c. systems; 20 cycles, or 50, or 100? It was only natural that discussion pertaining to the frequency question considered principally the relative merits of different frequencies from the point of view of electric machinery—generators, motors, and transformers—with practically nothing said of the then simple subject of electric power transmission.

Thus it is that the large electric power networks of today find themselves definitely committed to certain frequencies earlier chosen for various expedient reasons. Now there is a definite trend toward the use of more and longer transmission lines for carrying large blocks of power from generation centers to load centers. In this connection the question of transmission stability is supreme; hence it is considered justifiable to reopen the question of desirable frequency, and to study it from the long lines point of view. It is well known of course that transmission characteristics of a given system may be improved by the use of frequencies lower than those now in vogue; but no general study of the influence of frequency has been published.

From "Tuned Power Lines," (**No. 31-124**) to be presented at the A. I. E. E. Pacific Coast convention, Lake Tahoe, California, August 25-28, 1931.

While the fundamental transmission line equations are:

$$E_g = E_r \cosh \sqrt{ZY}\, l + I_r \sqrt{\frac{Z}{Y}} \sinh \sqrt{ZY}\, l$$

$$I_g = I_r \cosh \sqrt{ZY}\, l + E_r \sqrt{\frac{Y}{Z}} \sinh \sqrt{ZY}\, l$$

where

E is voltage
I is current
g subscript, signifies generator end of line
r subscript, signifies receiving end of line
Z is impedance per unit length of line
Y is admittance per unit length of line
l is length of line

it is most convenient to discuss transmission operation in terms of the general circuit constants:

$$A_o = \cosh \sqrt{ZY}\, l$$

$$B_o = \sqrt{\frac{Z}{Y}} \sinh \sqrt{ZY}\, l$$

$$D_o = \cosh \sqrt{ZY}\, l$$

$$C_o = \sqrt{\frac{Y}{Z}} \sinh \sqrt{ZY}\, l.$$

For ordinary transmission lines and for frequencies higher than about 10 cycles per sec., the value of factor $\sqrt{Z/Y}$ is practically constant and need not be considered as a function of frequency in this discussion. Hence the general circuit constants are proportional to the hyperbolic functions. However, if the resistance of the line in question is low compared with the reactance, and if the leakage from line to line is small, factor $\sqrt{ZY}\, l$ becomes purely imaginary and

$$A_o = \cos \sqrt{\mathbf{ZY}}\, l$$

$$B_o = j\, Z_o \sin \sqrt{\mathbf{ZY}}\, l$$

$$D_o = \cos \sqrt{\mathbf{ZY}}\, l$$

$$C_o = j \frac{1}{Z_o} \sin \sqrt{\mathbf{ZY}}\, l$$

EDITOR'S NOTE: Bold-face symbols (**Z**, **Y**) indicate absolute values (magnitude only) time relationships as indicated by angles omitted.

with $Z_o = \sqrt{Z/Y}$, the characteristic impedance of the line.

Thus it is made evident why low frequency gives good transmission characteristics. The desirable conditions are low voltage regulation under load, small charging current when lines are unloaded, and high synchronous stability. All three of these factors require a low value for B_o while synchronous stability requires also a value of A_o approximately unity. Both

of these conditions are obtainable with low frequency because Z and Y both are proportional to frequency, and as they decrease in value, the sine of $\sqrt{ZY}\,l$ decreases while the cosine of the same angle approaches unity.

Conversely undesirable transmission characteristics are encountered when the value of $\sqrt{ZY}\,l$ approaches $\pi/2$, because then the cosine approaches zero while the sine is near unity. Operation under such conditions is impractical because (1) regulation is so poor that with constant generator voltage the load is required to take practically constant current, (2) line charging current increases *indefinitely* as the receiving voltage rises, and (3) synchronous stability is possible only at extremely low power factor.

If the value of $\sqrt{ZY}\,l$ lies between $\pi/2$ and π, synchronous loading is quite impossible, but a static load may receive power. The static power limit (which is determined by voltage regulation and occurs at the load for which $d\,P_r/d\,E_r = 0$) becomes very large as $\sqrt{ZY}\,l$ approaches π, because $\sin \pi = 0$. For the same reason charging current to the line is very small; hence, transmission conditions are as good when the frequency makes $\sqrt{ZY}\,l = \pi$ as when the frequency is very low, except for the possible lack of synchronous stability.

An important point worthy of detailed consideration is that where the frequency used makes the value of $\sqrt{ZY}\,l$ slightly greater than π, and synchronous stability also is attained. The terminal steady-state conditions are identical when $\sqrt{ZY}\,l = k$ and when $\sqrt{ZY}\,l = k + n\,\pi$ with k representing any value of the function and n any integer. The truth of this statement for the idealized case under consideration is evident from the fundamental transmission line equations. The physical meaning is that transmission is good over a line the length of which is equal to a very small fraction of a wavelength of the transmitted voltage, and that it is equally good over a line the length of which is equal to a half wavelength or any multiple thereof. But this consideration includes only steady-state terminal conditions of a line without losses; certain modification is necessary before this statement may be considered to apply generally.

When line losses from resistance and leakage are not negligible it is best to use the hyperbolic-function form of general circuit constants. No change in the general understanding of conditions need occur, but the definiteness of the ideal line is lost; the power limit now is not infinite (as when $\sqrt{ZY}\,l = j\,\pi$) nor is synchronous stability either absolutely perfect or absolutely impossible. No longer is it quite true to say that $j\,\pi$ may be added to $\sqrt{ZY}\,l$ without changing terminal conditions. These things are nearly true, but not quite.

However, a point of far greater importance than line losses is the effect of terminal machinery. Even in the simplest system the general circuit constants will be modified by the generator, the transformers, and the load. If the apparatus at the sending end introduces a series impedance Z_1, and the receiving end apparatus introduces a series impedance Z_2, the general circuit constants become:

$$A_o = \sqrt{\cosh}\,\sqrt{ZY}\,l + \frac{Z_1}{Z_o}\sinh\sqrt{ZY}\,l$$

$$B_o = Z_o \sinh\sqrt{ZY}\,l + (Z_1 + Z_2)\cosh\sqrt{ZY}\,l + \frac{Z_1 Z_2}{Z_o}\sinh\sqrt{ZY}\,l$$

$$C_o = \frac{1}{Z_o}\sinh\sqrt{ZY}\,l$$

$$D_o = \cosh\sqrt{ZY}\,l + \frac{Z_2}{Z_o}\sinh\sqrt{ZY}\,l.$$

But if the line is long and the machinery is designed to have fairly low synchronous reactance, the only change in the constants that need be contemplated here is that a term must be added to B_o:

$$B_o = Z_o \sinh\sqrt{ZY}\,l + Z'\cosh\sqrt{ZY}\,l$$

where Z' is the total impedance of the machinery. This is an approximation, but it is almost true when the value of $\sqrt{ZY}\,l$ closely approximates π or is any multiple of π. It is not at all applicable if the value of $\sqrt{ZY}\,l$ approximates $\pi/2$, but it may be generally used because it applies whenever transmission characteristics are favorable.

Transient synchronous stability usually is investigated only after line and armature transients have died out; therefore as in the case of steady-state stability, only terminal line conditions are effective. A half-wavelength line would have the same order of transient stability as a low-frequency line except as the terminal machinery might be altered.

Traveling Waves

The nicest description of the operation of a line is in terms of traveling waves. The generator may be considered as imposing on the line a series of electromagnetic waves which travel on the line to be more or less reflected from the receiving end, setting up a wave train traveling back toward the generator. Where the line is short a reflected wave returns to the generator so quickly after its initiation that it still is very closely in phase with the wave leaving the generator. Under this condition the voltages and currents of the two wave trains will add algebraically at the load end (assuming the load impedance to have the same angle as the characteristic impedance of the line) and differ by only a small angle at the generator end. Therefore, if attenuation is low the load voltage will be almost equal to, and in phase with, the generator voltage.

If the line be longer there will be a correspondingly larger difference in phase relation at the generator

between the outbound and the returning wave. This involves trigonometric addition of effective voltages and currents at the generator and even with low attenuation, line regulation may be bad. However, if the line be of the proper length the reflected wave will arrive back at the generator just one cycle after its initiation there and consequently in phase with the next wave leaving the generator. Voltages and currents again will add algebraically and line regulation will be very good because the reflected wave will increase both end voltages equally. In this case as with the very short lines the load voltage will closely approximate the generator voltage (if attenuation is low) but 180 deg. out of phase.

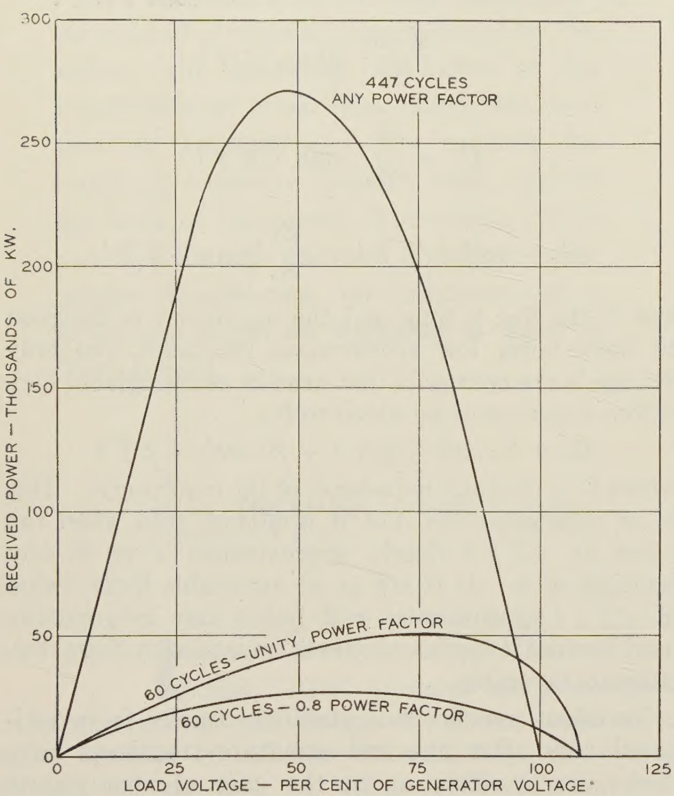


Fig. 1. Power limits of an operating 202-mi. 220-kv. line for normal 60-cycle operation and for suggested 447-cycle operation

The last few paragraphs have spoken of "long" and "short" lines. This refers to the electrical length of the line considering wavelengths rather than miles. However, a half-wavelength line is one for which the imaginary part of $\sqrt{ZY}\,l$ is $j\,\pi$, and hence it may be either a short line operating at high frequency or a very long line operating at normal frequency. Representative dimensions of a half-wavelength line are: 200 mi. long and 450 cycles, or 1,400 mi. long and 60 cycles.

The fact that apparatus at the ends of a line introduces impedance that increases the electrical length of the line already has been mentioned. It was shown that, approximately,

$$B_o = Z_o \sinh \sqrt{ZY}\,l + Z' \cosh \sqrt{ZY}\,l.$$

Since good transmission conditions demand that $B_o = 0$, it is desirable that

$$\sinh \sqrt{ZY}\,l = -\frac{Z'}{Z_o} \cosh \sqrt{ZY}\,l.$$

The hyperbolic cosine may be considered to be unity, either positive or negative. The lowest value of $\sqrt{ZY}\,l$ that approaches a solution of this equation will be between $\pi/2$ and π where the hyperbolic cosine will be negative and hence the values of frequency and length of line to be chosen should as nearly as possible make

$$\sinh \sqrt{ZY}\,l = +\frac{Z'}{Z_o}.$$

Consequently when terminal apparatus is considered, a shorter line or a lower frequency should be used than those given as representative in the preceding paragraph. If it is desired further to shorten the line or lower the frequency, more inductance may be introduced into the line, preferably in combination with static condensers across the line; this will result really in a section of "artificial line."

The presence or absence of synchronous stability for any given line may best be found graphically. Such methods, based on the circle diagram of the transmission line, tell at once the whole story of load limit, stability, regulation, and other factors. Although many statements in this paper now appear somewhat obscure in the light of the equations only, they become perfectly clear when the circle diagrams are studied. The diagrams unfortunately are too voluminous to be included, but Fig. 1 shows results obtained from such charts for a 202-mi. 220-kv. line having three 500,000-cir. mil cables spaced 15 ft. apart in a vertical plane; terminal apparatus not included. Under these conditions the value of $\sinh \sqrt{ZY}\,l$ reaches a minimum at 447 cycles. Whether or not there might be synchronous stability at this frequency depends upon the synchronous machinery; it is probable that there would be. It may be seen that the maximum power per phase to be received at 60 cycles by a unity power-factor load is about 50,000 kw. Lagging power factors are much worse, and leading power factors are not much better. With transmission at 447 cycles the maximum power (if supplied to a static load or to an induction motor) obtainable is more than five times the 60-cycle limit.

The reason for the peculiar action of a half-wavelength line is essentially quite simple. The capacitance of the line is so balanced against the inductance of the line that the undesirable effects of both disappear. On an exact half-wavelength line with no losses and without load, with voltage maintained by a generator, the voltage at the receiving end would be equal and

opposite to the voltage at the generator; in the middle of the line the voltage would be zero. The momentary charge at any point of the line would be proportional to the voltage; hence charging current would not need to be supplied from the generator, but merely would flow back and forth from one end of the line to the other each half cycle. Although there would be no current flowing at either end of the line, there would be a large current at the middle where the voltage would be low.

If load impedance were equal to the characteristic impedance of the line, current and voltage both would be constant along the line, but retrogressing angularly through 180 deg. The charging current would be passed on by each differential section of line to its neighbor as the voltage wave travels, finally to be used by the load.

If load impedance were less than the characteristic impedance, the current would be least at the middle of the line where the voltage would be highest. This resonant voltage rise is valuable because it makes efficiency and regulation of such a line better than could be obtained even from d-c. transmission; by proper insulation, reactance of the terminal machinery, and proper choice of the characteristic impedance of the line, resonant voltage rise may be prevented from becoming troublesome.

It is because of the interaction of the distributed inductance and capacitance that such a line is called a "tuned line." The similarity to a tuned radio circuit is striking.

As evidence that a tuned line will behave as predicted by the fundamental equations, power was transmitted at 60 cycles over a 1,468-mi. artificial line. The characteristics were those of the 220-kv. line previously described (which may be recognized as the Pit River line of the Pacific Gas and Electric Company, Calif.) and the potential used was 127 volts to ground, 0.001 of the real line voltage with a corresponding factor of 0.000001 for the power per phase as compared to the real line. The receiving end was arranged for loading with either a static impedance of any power-factor or with a single-phase synchronous motor. Extensive tests were made and the observed characteristics were found to be in close accord with the computed expectations; synchronous stability of the system was found to be exactly as expected. The half-wave-length line plus the reactance of the synchronous motor gave fair stability. The introduction of reactance into the motor leads was found to improve stability greatly, at the expense, however, of power limit. When the line was shortened to slightly less than a half-wave-length, it was impossible to keep the motor in synchronism; no synchronous power could be obtained although resistance loads continued to operate.

Fig. 2 shows reproductions of oscillographic records of voltages along the artificial line. Load impedance was somewhat less than the characteristic impedance of the line, and there was noticeable resonance. That the receiving voltage actually was lower than the sending voltage was due to the heavy load, the long line, and the unavoidable losses in the artificial line that do not properly represent a true line. Regulation would have been worse had the load been applied at an intermediate point.

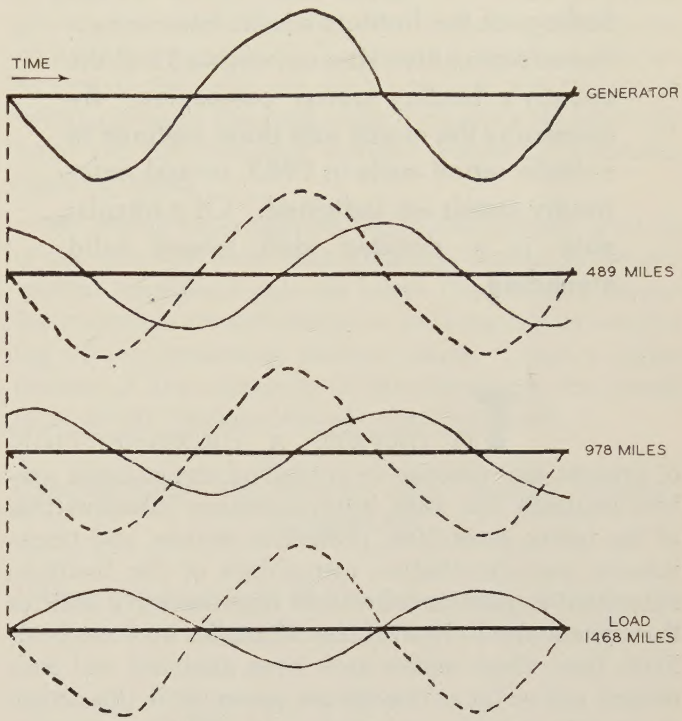


Fig. 2. Tracings from oscillograms showing voltage phase relations along a 1,468-mi. tuned line as compared with generator voltage (dotted)

While the subject of this paper considers the possibilities of the tuned line rather than its practical application and the details incident thereto, it seems quite reasonable to suggest that it is not at all impossible that 400-mi. transmission at 150 cycles will offer attractive economic possibilities. With the use of such a line of course motor-generator sets (probably induction machines) would be required for frequency-changing, but costly synchronous condensers would be eliminated. Even so considering the cost of building and maintaining 220-kv. lines it seems reasonable that even a relatively large amount of terminal equipment could be justified if it would eliminate one long line.

Bibliographic References

1. Tuned Power Lines, by H. H. Skilling; thesis, Stanford University, June 1927.

2. Characteristics and Stability of Transmission Systems, by F. E. Terman; thesis, Massachusetts Institute of Technology, 1924.

3. Power Limitations of Transmission Systems, by R. D. Evans and H. K. Sels, A. I. E. E. Trans., Vol. XLIII, 1924, p. 26.

4. Series Synchronous Condensers, by T. H. Morgan, A. I. E. E. Trans., 49, Jan. 1930, p. 162.

Present Practise in System Grounding

In this article are presented the principal findings of the Institute's joint interconnection subcommittee after canvassing 32 of the country's leading power companies. By comparing the results with those outlined in a similar report made in 1923, several noteworthy trends are indicated. Of particular note is a decided drift toward solid grounding.

TO OBTAIN A CROSS-SECTION of present day practise in grounding transmission system neutrals, the joint interconnection subcommittee of the power generation, protective devices, and transmission and distribution committees of the Institute submitted a questionnaire to 39 representative utilities throughout the United States; 32 replies were received. Data from these replies have been analyzed and condensed, and so far as possible are presented in this article in the form of tables and charts. In 1923 the protective devices committee through its subcommittee on grounding issued a similar report on the grounding practise of that day. Last year, however, it was felt that probably there had been sufficient change since 1923 to justify this second report.

The term "system" as used here may be defined as a certain number of circuit miles conductively connected; that is, connected by metallic ties. One company, therefore, may operate several systems, but on the other hand one system may overlap two or more properties. This designation is necessary because in the problem of grounding, the total mileage of the conductively connected transmission lines is of importance rather than the total mileage owned by any one operating company.

Methods of grounding adopted by the companies reporting are given in Fig. 1, which shows the longest single system and the average length of all the systems for each class of grounding. Where there are only two or three systems of one type they have been reported in full, since an average would not be representative.

From "Present Day Practise in Grounding of Transmission Systems," (**No. 31-63**) presented at the Middle Eastern District meeting of the A. I. E. E., Pittsburgh, Pa., March 11-13, 1931, and issued as the second report of the subject committee on grounding by the joint interconnection subcommittee of the power generation, protective devices, and transmission and distribution committees—F. C. Hanker, chairman. Personnel of subject committee on grounding:

C. A. Powell, chairman,	J. A. Koontz,	H. J. Scholz,
G. M. Armbrust,	W. W. Lewis,	H. K. Sels,
M. T. Crawford,	P. H. Robinson,	H. H. Spencer,
E. A. Hester,		E. R. Stauffacher.

Methods Used on Systems of 110-Kv. and Higher

From the charts it may be noted that 93 per cent of the systems of 110-kv. and above are classified as solidly grounded, showing a marked preference for this type of grounding. Noteworthy deviations from this general practise are indicated as follow:

1. One company reports solidly grounded neutrals on its 132- and 66-kv. systems except at three substations, where from 53 to 75 per cent of the transformer capacity is grounded.
2. Another company grounds only one-third of the transformer capacity at one station, but the entire bank capacity at other grounding locations.
3. A third company reports using a resistance at the generating end of its 220-kv. system, but a reactance at the receiving end. This arrangement tends to decrease the angular swing between the two ends in case of a fault to ground, thus improving system stability.
4. Still another company is using an impedance grounding device in its most recent 220-kv. transformer installation.

There appears to be a tendency in the higher-voltage systems to limit the ground current by either impedance or resistance, or by a partial grounding of the total transformer capacity.

Methods Used on Systems of 66-Kv. and Lower

On systems of 66-kv. and less, the solid grounding practise is less prominent. As may be noted in Fig. 1, in this voltage range 51 per cent of the systems are solidly grounded, 9 per cent are grounded through resistance, 8 per cent are grounded through either reactors or grounding transformers, and 32 per cent have free neutrals. Of particular interest in this immediate connection are that:

1. Two companies report cases of reactance grounded substations operated in parallel with solidly grounded substations. This is done to obtain the desired distribution of fault current through the two or more grounding locations. Grounding a small transformer solidly obviously may be the equivalent of grounding a large transformer bank through an impedance so far as ground current distribution is concerned.
2. Another company reports the use of a Petersen coil. This report shows a marked reduction in the number of lightning interruptions during the year in which this coil has been in service.

In the case of the 11- to 14-kv. systems, an almost universal practise is to ground only one generator on each bus section. Four companies report grounding the generator bus sections through grounding transformers, while two use grounding reactors.

Comparisons between Present and 1923 Practise

In analyzing the results contained in this report E. C. Stone, who is responsible for the preparation of a major portion of the 1923 report, has drawn some striking comparisons between the two. One of these comparisons is shown in Table I.

TABLE I—COMPARISON OF PRESENT AND 1923 METHODS OF TRANSMISSION SYSTEM GROUNDING

Method of grounding	Present report Mileage	Present report % of total	1923 report Mileage	1923 report % of total
Ungrounded	5,310	9.3	6,385	20.4
Solidly grounded	42,300	74.5	18,375	58.5
Resistance grounded	6,346	11.1	6,448	20.8
Reactance grounded	2,903	5.1	100	0.3
Total	56,859	100.0	31,308	100.00

While no radical changes in practise have been observed, some interesting trends are noted. The second report covers a total of nearly 57,000 mi. of transmission lines, as compared to about 31,000 mi. covered in the 1923 report. With the exception of approximately 5 per cent of the total mileage which is reactance grounded, all of the increase in mileage covered by the second report is solidly grounded.

In continuing Mr. Stone says that the present report clearly indicates a better understanding of the principles of system neutral grounding, of the fields for application of the various methods, and of the results to be expected. The points at which the neutral is grounded must be sufficient in number and so located as to permit adequate current flow regardless of the fault location. At the same time the neutral ground current must be limited to values which will not cause undue damage at the point of fault, and which will not produce system instability.

In discussing differences in grounding practise between systems operated at generated voltage and those operated at higher than generated voltage, Mr. Stone says in part that "of the 36,000 mi. of line reported on as operating at 34 kv. or above, approximately 34,000 mi. or 90 per cent are solidly grounded, while for the 21,000 mi. operated below 34 kv., only 55 per cent are solidly grounded. There are definite reasons for this difference in practise: on the high-voltage lines solid grounding gives greater benefits from the insulation standpoint, while at the same time the ground currents in relation to system capacity are relatively low; on the lower-voltage systems the fault ground currents are relatively large and the insulation benefits from solid grounding relatively small."

Mr. Stone expresses the belief that further analysis of the data will show that while the over-all grounded-neutral impedance may be lower than before, ground fault currents are still limited in value by the sectionalizing of the generating station buses. Thus a larger element of line impedance is introduced into the ground fault circuit than has been the case heretofore.

Ground-Wire Protection and Tower Footing Resistance

Over-all practise in the use of ground wires for the protection of transmission lines is shown in Fig. 2.

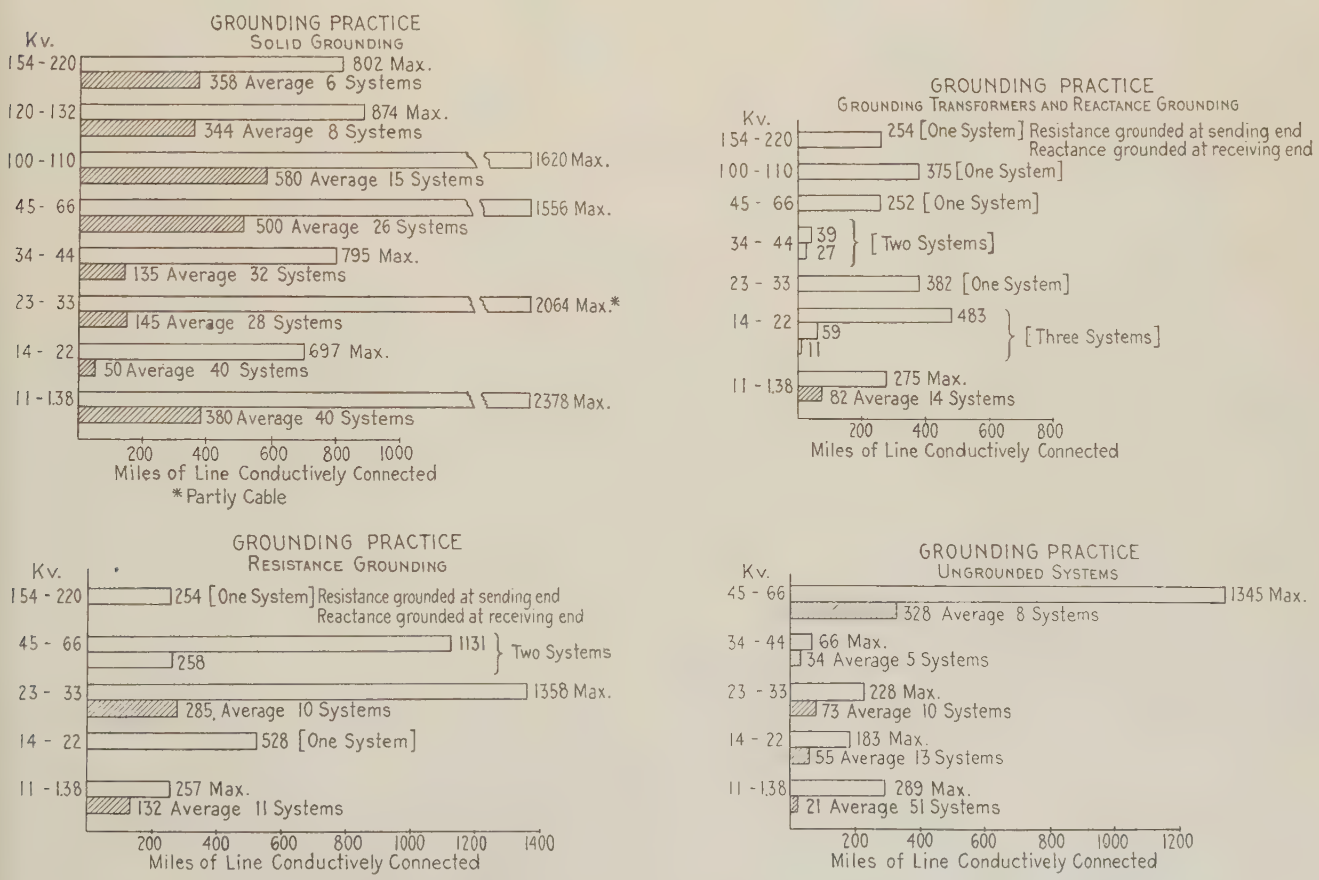


Fig. 1. Graphical summary of present day system grounding practise for different voltage ranges

In this graphical summary two different percentage bases are used as follow:

1. The total length of all lines reported in a given voltage class is taken as 100 per cent, and the mileage of lines protected by ground wires computed as a percentage of that total.

2. The total mileage in a given voltage class of each individual company is taken as 100 per cent, and the mileage of protected lines expressed as a percentage of this total. Averages of these percentages for each voltage class are the values given in the chart.

The former gives the practise of the country as a whole; the latter tends to show the opinion of transmission engineers better than the first value, perhaps, because the short systems are given the same weight as the long systems.

In protecting a line against direct lightning strokes, performance of the ground wire depends upon its receiving the direct strokes and conducting the energy to ground without causing flashovers to the line conductors. This depends upon the ability of the ground wires to remain at a low potential, which in turn is dependent largely upon the tower footing resistance.

Replies to the question regarding tower footing resistance, however, indicate that but few accurate data are available. Hence no average figures of any value can be given either on the basis of general territory or nature of soil. One company reports a range of from 1 ohm to 58 ohms over a restricted territory. The extremes reported by the seven companies replying to this question are 0.05 ohms and 300 ohms; the average 22.5 ohms.

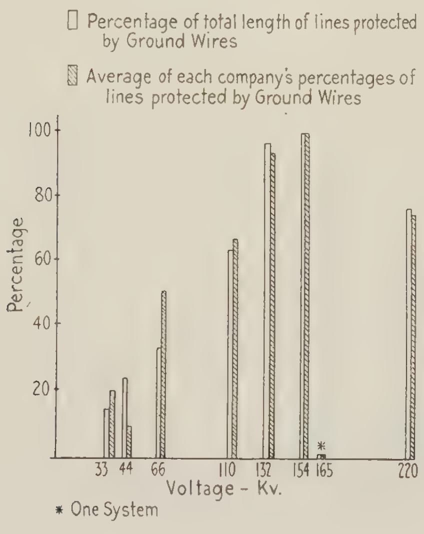


Fig. 2. Graphical summary of present day practise in the use of ground wires

Simultaneous Faults at Different Locations

In reply to the question, "do you have evidence of simultaneous faults at different locations," 25 replies were received. Of these, sixteen companies report no evidence; two report less than 1 per cent; three report 1 per cent; one reports 5 per cent, and three give replies as follow:

1. One company reports having trouble on a 300-mi. 66-kv. system until it was grounded. The neutral was found to shift to 80 per cent of the line-to-ground voltage at the middle of the section when one conductor was grounded.

2. A second company reports no evidence of simultaneous faults on their 132- and 220-kv. systems. One 66-kv. and two 22-kv. systems show 1 per cent or less, one 66-kv. system, 15 per cent, eight 26-kv. and three 13-kv. systems (mostly overhead) show 33 per cent, as indicated by relay operations.

3. A third company operating an ungrounded system reports conclusive evidence of arcing grounds without stating any figure for this type of fault.

In all cases, the evidence was taken from relay operations or from automatic oscillograph data.

In discussing this phase of the report Mr. Stone says that double simultaneous faults at different parts of a system are of particular importance because of the difficulties in many cases of providing relaying to isolate such faults without service interruption. Naturally in an ungrounded system simultaneous faults are charged to arcing grounds. In a properly grounded system arcing grounds should be impossible so that simultaneous faults here may be assumed to be the result of the rise in voltage on two phases when the third phase is grounded. The question then arises as to whether a relatively small reduction of fault voltage by lowering the ground impedance will correct the situation, or whether the insulation should not be sufficient to withstand these excess voltages for the short periods required for relay operation. The solution to this perplexing problem does not seem to be in reducing the impedance of the neutral ground circuit but rather in raising the system insulation to a level which will permit it to withstand the overvoltages prescribed by standard A. I. E. E. tests.

Types of Faults

Regarding the division of the faults into the four classes, (1) one conductor to ground, (2) two conductors to ground, (3) phase-to-phase short circuit, and (4) three-phase short circuit, 27 replies were received. These are given in Table II as percentages of the total number of faults. The figures listed include both overhead and underground lines.

Ground Current and Relay Operation

All companies except two report sufficient current for relaying purposes. In these two exceptions a lack of proper selectivity was encountered at times of light load. Loss of synchronous load caused by ground faults is rare; only seven companies report having experienced this occasionally, while one company reports making changes in its relay equipment to rectify this difficulty.

TABLE II—DISTRIBUTION OF DIFFERENT TYPES OF FAULTS ON 27 SYSTEMS				
	One cond. to ground	Two cond. to ground	Ph.-to-ph. short circuit	Three-phase short circuit
Maximum	97	45	54	36
Average	69	14	11	6
Minimum	30	0	0	0

In concluding his discussion Mr. Stone says that the problem of system grounding is only one phase of a greater general problem facing power engineers today—that of reducing insulation failures. However, because of the extensive research in progress, and of the definite advances being made, he urges an optimistic point of view on this subject.

Engineering and Human Happiness

By
W. S. LEE President* A. I. E. E.
ROY V. WRIGHT President A. S. M. E.
ROBERT E. TALLY President A. I. M. E.
H. HOBART PORTER Chairman Engineering Foundation
FRANCIS LEE STUART President A. S. C. E.

THROUGHOUT THE AGES man has dreamed of relief from toil, of the bountiful supplying of his needs, and the attainment of comfort and luxury. He has struggled toward an ideal state in which these satisfactions might be enjoyed by all. From their beginnings the literature of all peoples has contained many expressions of man's aspiration for the "better life." Since happiness ever has been a condition earnestly desired by human beings the time seems propitious to ask—what has engineering done for humanity's progress toward this objective? What have engineers by their applications of scientific knowledge, by their control of nature's forces, by their improved and ever increasing utilization of new raw materials, or by their salvage of former wastes accomplished for the good of mankind.

For two years Admiral Byrd maintained 82 men under the most inhospitable climatic conditions to be found on earth! And they were comparatively comfortable and were happy in their adventurous enterprise. In contrast to the utter isolation of earlier exploring parties is the striking fact that throughout the period, persons in America and other regions thousands of miles away talked with him easily. Millions of men in all civilized countries daily heard by radio or read in their newspapers of the achievements, the dangers, the sports of this intrepid band.

On May 12, 1931, Capt. Frank M. Hawks flew from London to Berlin, arriving there ahead of a telegram despatched coincident with his start. On July 2, 1931, Gatty and Post completed in less than nine days a trip around the world. Startling exemplifications of engineering developments, these, and yet readers of morning newspapers hardly so much as wondered at the feats.

Daily, on the tables of millions of Americans of modest incomes are to be found articles of diet brought at low cost from places near and far by the most efficient transportation facilities the world ever has possessed. In the area known as continental U. S. A. perhaps as many as two million savages formerly sustained themselves precariously by hunting, fishing, and the crudest of agriculture. Within the same boundaries some 60 times as many human beings now possess means for supplying all their needs abundantly, together with many comforts and luxuries to say nothing of export. These multitudes also have facilities for education, many fine collections of art, and vast riches of other kinds such as even the kings and nobles no longer ago than when our grandfathers were boys could not have commanded.

Yet these items mention only a few examples of the many benefits which science, engineering, and chemistry have made possible within a half century to and through

*Retired from office July 31, 1931.

An introduction to a series of articles in the course of preparation under the sponsorship of The Engineering Foundation. Not published in pamphlet form.

industry and commerce. How came these things to be looked upon as being so commonplace?

Modern man has come to accept as matters of course, one after another: unfailing supplies of good water conveniently delivered; sanitary disposal of sewage and refuse; more and better artificial light; steadily cheapening power conveniently applied; greatly improved facilities for communication (some of them almost instantaneous over long distances); better built and better equipped houses and working places; many means for rapid and enjoyable individual travel; commercial transportation remarkably low in cost and not only speedy, but also capable of carrying many commodities not formerly transportable; high explosives safe and convenient for many uses; recording devices that include besides the printing press, the camera, the phonograph, the "talking" film, and almost innumerable equipments and methods for special purposes; machinery for preparing and preserving foods in great variety; machines for making all forms of clothing and the materials therefor; novel equipment for entertainment and sports; farming implements; and tools of capacity, power, precision, and delicacy beyond the conception of persons unfamiliar with modern manufacturing.

These all are products of science, engineering, and applied chemistry, given to mankind through industry and commerce. It is of particular importance to note well also that progress made by science and engineering is ground *permanently* gained, a place from which to "take off" for further advances. Standards of living constantly are being elevated.

However, even the engineers, chemists, and industrialists who have provided present day society with its astounding equipment have given relatively little thought to the deeper effects of their achievements toward the lives and characters of men and communities and peoples. Of the painful present effects of individual and concerted neglect of immaterial (or spiritual) consequences, Progress is demanding a reckoning. Capacity to produce has been achieved; and the ability to discover and develop more and better goods and services made part of the world's present equipment.

But, how to divide the benefits of engineering progress properly has not yet been learned sufficiently well to permit maintenance through well ordered production, distribution, and consumption without disastrous fluctuation of enjoyment. Perhaps the methods of engineering and science could be applied beneficially to some features of this problem also, supplementing progressive business methods.

In an effort to effect a worthwhile contribution in this direction, The Engineering Foundation has invited an imposing array of highly qualified persons to comment upon various phases of the general subject of engineering developments' relationship to human progress and happiness. The first of these articles appears here; others are expected to eventuate.

Has Man Benefited By Engineering Progress?

A noted research worker, head of a modern laboratory, decides that the life of the future will simulate the life of the ancients; built, however, on a foundation of modern engineering.

By
C. E. KENNETH MEES Eastman Kodak Co., Rochester, New York

IN CONSIDERING the fundamental problem of whether engineering progress—under which term the engineer probably will modestly include the development of science and the arts through the ages—has been on the whole a benefit to mankind, it is necessary first to define what is meant by "benefit." This involves a consideration of the aim or purpose which may be ascribed to man's life on the earth.

This aim depends upon the person ascribing. The biologist probably would say that that purpose was the reproduction of the species; the mystic that the chief aim of man was to worship and glorify his maker; the materialist that it was to achieve happiness; while the Greek philosopher would say that it was to increase his knowledge of good. In considering the effect of scientific progress through the ages, therefore, one must consider its effect upon each one of these aims as well as upon any others which may occur to him.

If the purpose of the race is to multiply the species, then engineering progress certainly has been successful, since the population of the world is increasing rapidly and promises to become a very great problem in the near future.

To the mystic, the advance of civilization seems to offer no consolation. If man is more ethical than he used to be, he certainly is becoming less religious, and whatever future developments may show, at present engineering can claim no triumphs in the field of religion.

This leaves only the last two categories: the acquisition of happiness by the individual, and his progress towards a knowledge of good. It is under these two headings that my colleagues would think that engineering progress has been of benefit to mankind, including under the heading of *happiness* all the material benefits

First of a series of articles written expressly for The Engineering Foundation and released to Electrical Engineering for publication. Not available in pamphlet form.

which it has conferred, and under the heading of *good* all the cultural and intellectual benefits.

Happiness, however, is not a thing which depends upon the possession of material things beyond a certain minimum. Happiness depends only upon the spirit, provided that spirit is not oppressed by the material situation of the body; it is fundamentally a by-product of activity of some kind. A man can be happy in arduous toil or in nerve-racking sport; he can be happy in intellectual relaxation; he can be happy, passively happy at any rate, in mere contemplation. Has not almost everyone heard of contented cows?

The one great gift of science to the world has been the diminution of disease. Diseases due to micro-organisms, especially those which afflict the young, are diminishing rapidly as a result of the exploration of their natures and an application of the discoveries made. In their turn diseases due to deficiency are being diminished and eventually will be destroyed. One may look forward without doubt to a world in which widespread pestilences can exist no more. This certainly is a benefit to man which may be claimed by engineering.

But apart from this, I doubt if the life of the agriculturist in any country today is any happier than was that of a peasant in the Nile Valley 4,000 years ago. It is true that in the more advanced countries he has had great aid in his struggle with the pests that afflicted his crops and that in many cases as the result of applied engineering, he has had irrigation supplied, the first engineers to do this having lived more than 40 centuries ago. Moreover, in a few countries, and especially in the United States, machinery has reduced the heavy labor of the old-time farmer and has added many comforts to his domestic life. But, while machinery assisted the farmer at first, it now is undermining his status and perhaps may end by eliminating him. Hence the old normal life of man in which he cultivated the soil and lived on the crops, exchanging a small surplus for goods produced by somebody else, is passing possibly never to return. Engineering can produce that surplus and supply it to the consumer at a far lower labor cost than can the individual producer, and throughout the world economists and statesmen are considering the future of the farmer with troubled faces, remembering that farming is the normal life of man and that any other life for the mass of mankind involves tremendous readjustment in our whole economic and social system.

To turn from the agriculturist to the town dweller and even to the intellectual of the city, will any student of history agree that the inhabitants of an American city are any happier on the whole than those of a Greek or a Babylonian city of the past? This is a thing difficult to assess, but for myself, if I could exchange the life in a modern city for a life in Athens of the Periclean age or Thebes under the eighteenth dynasty, I think that undoubtedly I should accept it. In those days there was more leisure, more opportunity for the exchange of ideas, less pressure, and less emphasis on material things. There is little that a man can get today which he could not have had in Athens. It is better to walk a short distance than ride a long one. It is better to talk to one's friends and attend to one's business in a leisurely manner than to dash off to the office, returning in the evening tired. Life in a small city in a house with a garden is better, it seems to me, than is a life in the inevitable apartment of the large city. Perhaps it may be claimed that the urban worker has gained many comforts by the progress of engineering and that in recent years, at any rate, life in the sordid slums of our great cities has been mitigated by technical progress. It may be true that a factory operative in modern American textiles has a much greater chance of happiness than a corresponding operation in an Old World mill town of 70 years ago. But it seems to me that under those factory conditions of the first half of the nineteenth century the nadir of human existence was reached and that more properly the lot of the modern worker might be compared with the poorer classes of the great cities of the ancient world before the machines of the engineer had begun to replace the handwork of the craftsman. And I feel that a freeman of the Roman Empire, an apprentice of the middle ages, and perhaps even a Grecian Helot, had at least as good a chance for happiness as have most modern factory workers.

When one turns to the highest aim of mankind, that which we may define as progress in culture, it seems to me that the modern world is very much less satisfying than the world of the past. Culture primarily demands leisure, and at the present moment, at any rate, leisure is conspicuously lacking; it demands intellectual detachment, and intellectual detachment is exceedingly hard to accomplish.

Some of my colleagues may urge that engineering progress has contributed to international understandings; to this I would enter a definite objection. I doubt if nations ever have hated one another so fervently as they do at the present moment. Looking back on history, one can watch the waxing and waning of international good feeling; at the present moment it seems to me it is nearly at a minimum.

What then of the future? Shall scientific progress stop in an effort to get back to a world of the past? To this I should say that such discussion is futile. Scientific progress will continue and will be accelerated. In my opinion acceleration will end finally in a revolution of the whole social and economic life. What form that revolution will take and what type of life will come out of it, cannot be foretold, but I believe that in some respects the life of the future will be closer to the life of the past than to the life of today. I believe that a large portion of mankind will abandon the feverish quest for material things and will employ greater leisure for the development of art and the cultivation of

its soul. This Utopia of the future may be possible primarily because of engineering progress, and in that sense engineering progress may be at some time a blessing to mankind. Up to the present time I doubt whether on the whole it has been.

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles published in this series.

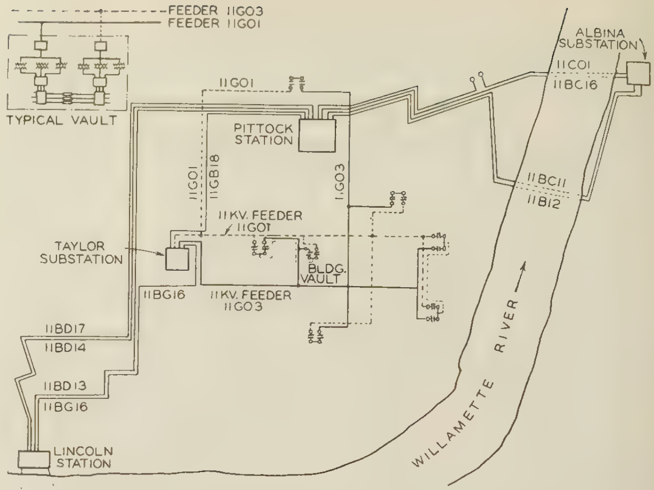


Fig. 1. 11-kv. underground distribution system of the Northwestern Electric Company, Portland, Oregon

An A-C. Network for Portland, Oregon

An underground distribution system comprising duplicate 11-kv. primary feeders and an isolated network secondary system is adopted to supplement existing d-c. and radial 2.4-kv. systems. Provsion for burn-off is not made; special junction boxes were developed.

By
S. B. CLARK
Non-member

N. W. Electric Co.,
Portland, Oregon

IN COMMON with other utilities serving areas of relatively rapid load growth, the Northwestern Electric Company which serves portions of Portland, Oregon, recently was faced with the problem of congested underground feeders and the prospect of further load growth. To supplement the three-wire d-c. Edison system originally installed in 1914 to serve the downtown underground district, the company placed in service in 1920 several radial a-c. three-phase 2.4-kv. primary feeders, later networked for load transfer purposes. At the same time radial secondary circuits connected to duplicate single-phase transformer banks for 120-240-volt lighting, and to closed-delta banks for isolated power loads, also were installed. In 1930 the company completed further steps in its distribution system development, initiating an 11-kv. duplicate primary, 125-216-volt Y radial secondary distribution system differing in some respects from any system now in use.

In making the economic studies preceding the latest trend in the company's distribution practise, due consideration was given to the present a-c. and d-c. sectional load density and to capital investment in the existing distribution systems. Eliminating d-c. distribution as a factor in future demands, three types of a-c. distribution plant were considered, with capacities based upon anticipated load growth and costs estimated on each for purposes of economic comparisons. The three types were:

1. Expansion of existing 2.4-kv. three-phase primary network with radial single-phase and three-phase secondary circuits.

2. Expansion of existing 2.4-kv. three-phase primary along radial lines with four-wire 120-208-volt Y network secondary.

3. Installation of 11-kv. feeders with 125-216-volt Y secondary; the 11-kv. feeders to be (a) radial, (b) loop, or (c) duplicate.

Comparative cost data which influenced the final selection of system are given in Table I. All costs of course are based upon actual conditions peculiar to Portland, including the Pittock station's limited capacity together with its correspondingly large capital investment in 2.4-kv. station primary equipment and the large capital investment in a reliable 2.4-kv. distribution system, neither of which could be discarded within acceptable economic limits. Load forecasts indicated that the area of some 40 city blocks adjacent to the station eventually would develop a load demand equivalent to the existing capacity of Pittock station. Thus the development plan decided upon withdraws some of the longer 2.4-kv. feeders from sections outside that adjacent area, releasing station and feeder capacity for area use and picking up with the newer distribution plant the outside sections as well as extremely heavy concentrated loads within the adjacent area.

The cost data of Table I reveal the reason for the selection of the 11-kv. duplicate primary, 125-216-volt four-wire radial secondary for the Northwestern com-

From "A-C. Networks in Portland, Oregon," (**No. 31-M2**) to be presented at the A. I. E. E. Pacific Coast Convention, Lake Tahoe, Calif. August 25-28, 1931.

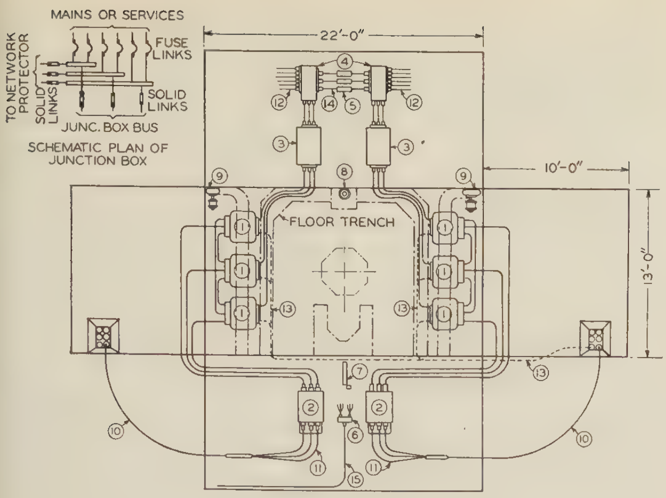


Fig. 2. Schematic arrangement of the floor and four walls of a standard 11-kv. underground vault

(1) 100-kva. 11,000/125-216-volt, single-phase transformers. (2) Three-position submersible grounding switch. (3) 1,200-ampere automatic network switch. (4) Four-way three-phase junction box. (5) Single-phase paralleling reactors. (6) Pilot-wire cable junction box. (7) High-water float and control switch. (8) Sump-pump float control. (9) Sirocco ventilating fans. (10) Three-conductor lead-covered 11-kv. cable. (11) Single-conductor lead-covered 11-kv. cable. (12) 240-volt mains to sec. network. (13) System neutral. (14) Junction-box bus. (15) Pilot cable.

pany's Portland underground system. The slightly better cost showing of the 11-kv. loop system could not be realized practically, because proper sectionalizing switches with pilot relays and control were not available from manufacturers without appreciable development work. In passing it should be noted that had existing conditions been more favorable to the adoption of a more compact system, there would have resulted appreciable reduction in costs per kva. as compared with those of Table I.

The general plans of the 11-kv. tie-lines between the Lincoln steam plant, Pittock station, and Taylor and Albina substations, as well as the tie-lines for the network vaults now in service, are shown in Fig. 1. The Albina substation is the general distribution point for the company's hydroelectric power. Three-conductor 250,000-cir. mil, 15/32-in. paper, type-H cable was installed as the standard 11-kv. feeder. As may be noted in Fig. 1, taps from each feeder cable are carried into each vault with no switching protection provided except station circuit breakers between the station bus and station transformers. Either three single-conductor 250,000-cir. mil or 350,000-cir. mil paper cables (three cables installed in one duct and paralleled where load conditions demand) were adopted as maximum standard for secondary mains.

The standard vault provided for in this system plan is 22 ft. in length and 16 ft. in width with 10-ft. headroom. They are designed to accommodate duplicate banks of three 200-kva. single-phase transformers, with the secondary leads from each bank networked within the vault. However, the installation of the 200-kva. units will be made only when and as required by heavy concentrated building loads fed directly from the vault. In many cases three-phase transformers could have been utilized more economically than single-phase unit, but space restrictions in many important locations precluded the use of the necessarily large manhole openings.

Removable cell walls are provided to separate the 11-kv. transformers from the rest of the vault. The transformers used are of standard submersible network type with special low-voltage windings for providing the 125-216-volt Y instead of the usual 120-208-volt Y service. Three 2.5 per cent voltage taps are provided for increasing secondary voltage and special insulated studs extending through the transformer casing are provided to permit the expedient evolution of a three-phase closed-delta bank in the event of an extremely heavy power load being encountered with factors unfavorable for connection to the four-wire system. All transformers have an inherent impedance of 5 per cent.

General details of vault design are shown in Fig. 2. Special grounding and other safety precautions have been observed and a special pilot-light signal system conveys information to the Pittock station operator revealing to him the open or closed position of the 11-kv. network protectors, the presence of high water, or dangerously high temperatures in cables or transformers. This pilot system eliminates the necessity of constant inspection for operating information and also serves as an automatic indication of network switch position when a feeder is taken out of service.

Table I—Comparative Cost Data on Distribution Systems

System	Construction costs		Carrying charges		
	Per installed kva.	Per effective kva.	Investment 14% per kva.	Energy losses per kw-yr.	Total
D-c. Edison	$137.00	$137.00	$19.21	$20.24	$39.45
2.4-kv. a-c. radial	101.00	101.00	14.15	5.00	19.15
2.4-kv. a-c. radial primary with network secondary	117.00	119.00	17.00	5.00	22.00
11-kv. radial primary with network secondary	77.00	78.00	10.80	2.20	13.00
11-kv. duplicate primary with radial secondary	68.00	70.00	9.50	2.20	11.70
with network secondary	79.00	81.00	11.10	2.20	13.30
11-kv. loop primary with radial secondary	67.50	69.00	9.45	2.20	11.65
with network secondary	78.70	80.00	11.00	2.20	13.20

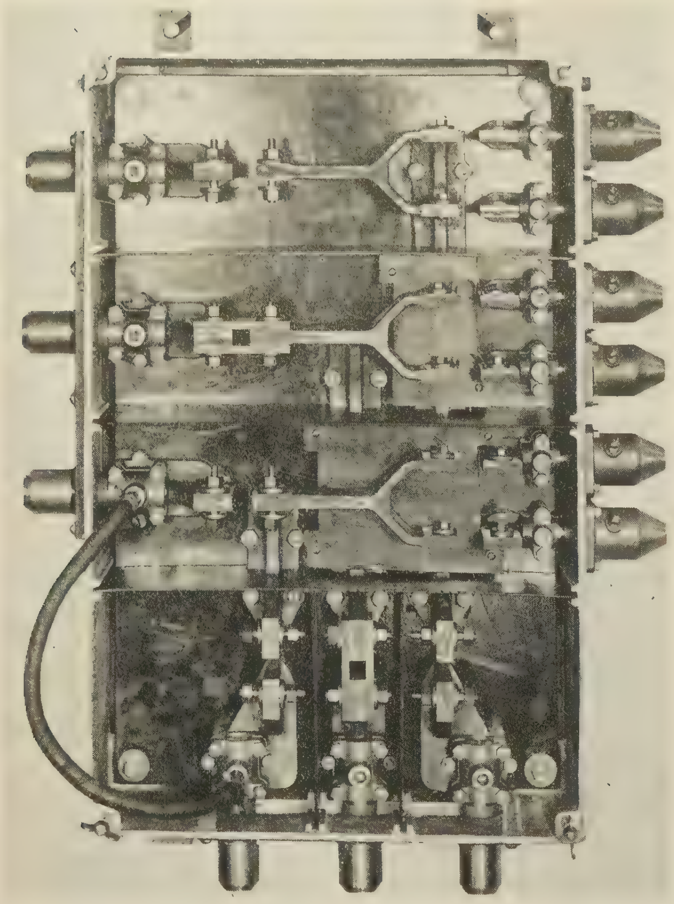


Fig. 3. Company's special design of junction box

During the study of existing network systems it became apparent that particularly along the Atlantic Seaboard, networks were being designed with an inherent ability to clear all secondary faults even at the expense of appreciable extra investment. However, on the basis of data available covering eastern operating experiences and construction costs, and on the basis of Portland operating experience which indicated that secondary faults rarely occur, it was decided that for the Portland system, additional capacity to provide for the burning clear of secondary-main faults was unwarranted. It was decided also that until results are available from wider operating experience, large solid-type networks should be avoided.

In view of the foregoing, and following the practise of some companies to insure against transformer damage or severe secondary cable burn-outs (especially where cables are mechanically injured) junction boxes were provided between network switches and outgoing conductors with both mains and services heavily fused. The first of these boxes to be installed were of standard manufacture and 1,200-ampere capacity; but the design did not prove to be entirely satisfactory. Thus a new design (Fig. 3) was developed and to date is assembled in the company's shop. The non-submersible case is of aluminum alloy (92 per cent aluminum, 8 per cent copper). Buses and terminals for the buses between boxes, and terminals for connection to network switches, have a normal rated capacity of 1,600 amperes, while the six terminals for main and service connections have a normal rated capacity of 600 amperes each. All unit parts are mounted on a separate practise of 1-in. ebony asbestos with barriers between conductors of opposite polarity. Buses are of single castings machined for linkage to network switch leads, junction box, connecting buses, and fuse positions to main and service leads. Submersible terminals are provided only for service and main connections to insure against moisture penetrating the paper insulation should the junction box become submerged. Where conditions require capacity for a heavy power load, and with a direct

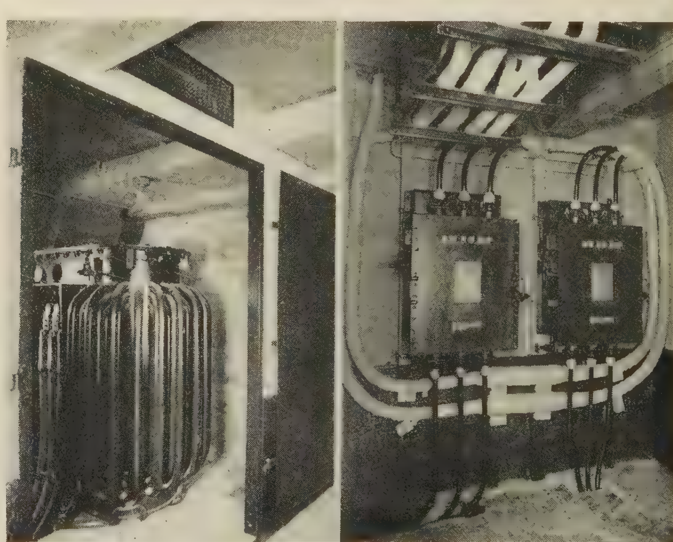


Fig. 4. 11-kv. basement vault construction

service into a building, power service is supplied from one junction box, while lighting service is taken from the other. Under these conditions the necessary reactance (item No. 5, Fig. 2) is connected in the buses between the two junction boxes.

All new 11-kv. vaults are made waterproof in so far as possible, and without sewer connections although a small automatic sump-pump is provided to care for possible leakage. As ventilation becomes necessary a mechanical system of forced ventilation is installed. This ventilation system has been in use for some time on the 2.4-kv. distribution system, and includes a motor driven fan which discharges air through covered trenches in the vault floor, from which ducts lead into low metal cone housings at the bottoms of the transformers, thus forcing a thin sheet of air upward along each transformer casing, providing an effective and efficient means of cooling. The fan units are thermostatically con-

trolled by transformer oil temperature, and as previously mentioned a high temperature alarm at the Pittock station is sounded by means of a contact-making thermostat in each transformer bank upon the event of dangerously high temperatures.

Vaults for 11-kv. primary, 125-216-volt Y secondary service often are placed within buildings, but under such circumstances cannot be standardized as readily as those in street areas, although of course certain identical features are retained. One example of a "near standard" is in service 64 ft. below street level in the subbasement of a department store. This vault is 25 x 27 ft. in plan with cell compartments for each transformer, and serves a demand of 775 kw. for lighting and 1,500 kw. for power.

The vault is supplied by duplicate feeders (Fig. 4 shows typical construction) each connected to two 450-kva. three-phase 11-kv./125-216-volt vault-type transformers connected delta on the primary and Y on the secondary. Secondary leads from each transformer feed through floor trenches to 1,600-ampere, three-pole open-type network protectors on one of the cell walls (Fig. 5). The load sides of the network protectors are connected to light and power buses suspended from the ceiling, the two buses being tied together by a smaller auxiliary bus to which the network mains from the street are connected. On this auxiliary bus, reactance is installed between the power and light buses to prevent objectionable voltage drop on the building lighting circuits.

In this installation all metering is accomplished by current transformers installed in the secondary light and power buses. Temperature and switch position indicators at Pittock station are provided as before mentioned, and telephone connection is provided between the vault, Pittock station, and the underground superintendent's office. Forced ventilation at the rate of 1,000 cu. ft. of air per min. serves to keep temperatures within desired operating limits. This building vault is networked through 1,600-ampere submersible network protectors to a street vault which contains six 150-kva. single-phase transformers with standard 11-kv. vault secondary connections.

The 11-kv. duplicate primary and isolated network secondary system has been in operation for several months, and to date no trouble excepting the necessary adjustment of network protector relays has been experienced. Three-phase motor operation has been entirely satisfactory on the four-wire system, even on the longer secondary mains. In cases where the d-c. or the three-phase a-c. power has been changed to the four-wire service, booster transformers to obviate any possible chance of voltage complaint have been installed in all cases where large ranges, bake ovens, lead melting pots, or other similar concentrated loads are encountered.

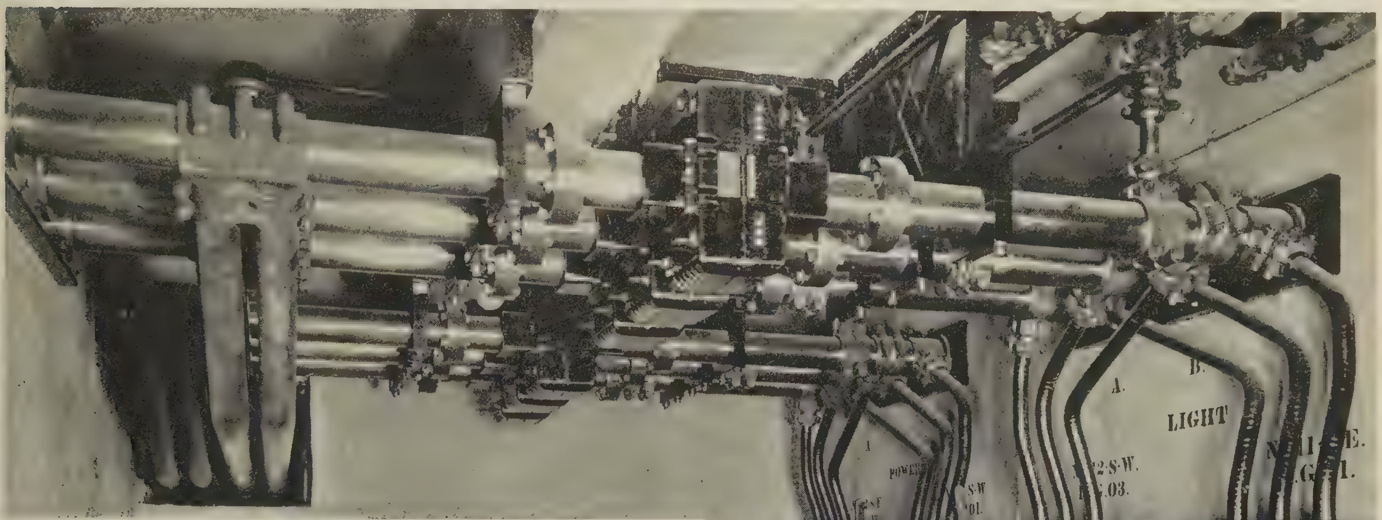
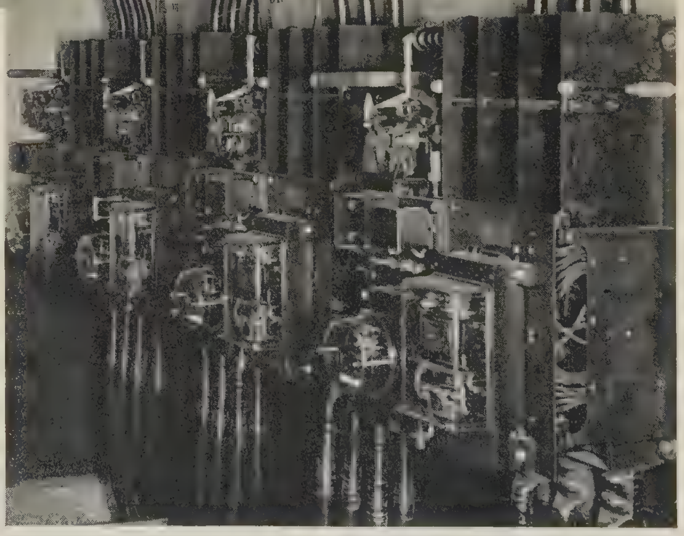



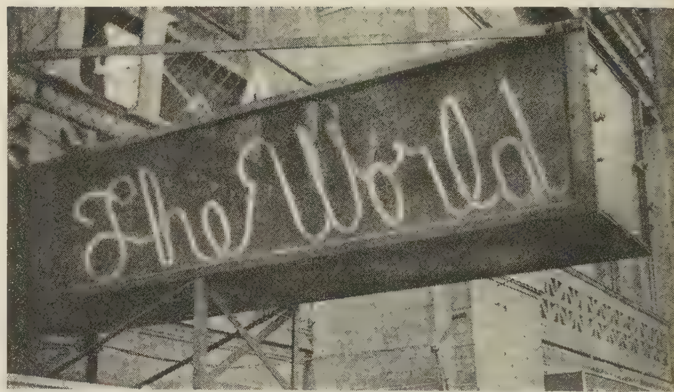
Fig. 5. **Secondary construction in basement vault for store light and power service**

Development of Gaseous-Tube Lighting

By
D. F. MOORE
Fellow A. I. E. E.

Consulting Engineer
East Orange, N. J.

Although what appears to be a multiplicity of different types of gaseous-conduction lamps have been developed, these are classified into a total of only sixteen groups. Outstanding developments in this class of lighting also are described in this article.



An early (1905) script sign

ALTHOUGH LIGHTNING represents a form of gaseous-conduction lighting which was observed by man millions of years ago, there are in practical use today only two general classes of gaseous-conduction devices. These two classes include (1) the non-luminous type—X-ray tubes, radio, and similar tubes, and (2) the luminous type to which this and the succeeding article are devoted. Although hundreds of devices in this second general classification appear to differ greatly in appearance and construction, they can be divided further into two general classes: (1) those of the positive column, and (2) those employing the negative glow. If each of these two classes is further subdivided into high- and low-voltage lamps, respectively, and these again subdivided into convenient groups, a total of sixteen groups of these lamps will result and under these practically all gaseous conduction tubes of the luminous type can be classified. (See accompanying tabulation.)

Perhaps best known among the various types of lamps are those of groups 1 and 9. Those of group 1, composed of script signs now popularly called neon signs, have grown so numerous during recent years that they have been said to "paint red the main streets of the whole world." Those in group 9, of which the ordinary photographer's mercury-vapor lamp is a familiar example, came into use as early as 1895. Although at present these two groups are the most widely used of any of the sixteen, it should be borne in mind that any group at any time may assume increased importance.

The complete history of luminous gaseous-conduction lamps would read in much the same manner as that of many other outstanding developments of the present age. Like other developments, the present state of the art has been made possible only through a long period of research, many different investigators working independently and contributing to some one particular phase of the problem. It may be interesting, however, to note a few of the outstanding achievements.

What may be regarded as a starting point of the present development in script signs took place as far back as 1858. A glass tube smaller than a lead pencil had a platinum wire melted into each of its ends; after most of the air within the tube was removed it was touched to a high-voltage frictional machine and its interior immediately assumed a luminosity of pinkish hue. About a year later the air in the tube was replaced by pure gases, while fourteen years later a similar tube was lighted from an induction coil which in turn received its current from a primary battery. This type of apparatus persisted until about 1890, when efforts were initiated to devise a lamp of this type which would operate from a low-voltage house-lighting circuit. Continued and persevering effort along this line has resulted in the present state of development of the low-voltage lamps; many of the outstanding features mentioned in the following paragraphs are the direct results of such efforts.

Mercury-vapor tubes as mentioned previously were first brought out in 1895. These early tubes operated on low voltage but required momentary high voltage for starting the discharge. The next few years witnessed some accomplishment in other directions, and in 1899 tubes about 1¾ in. in diameter and about 8 ft. long, provided with external electrodes, were used to light a three-story factory building by tuning them to reso-

Written specially for ELECTRICAL ENGINEERING and based upon an oral presentation before the Illumination Group of the New York Section, A. I. E. E., March 3, 1931. Not published in pamphlet form.

Classification of Gaseous Conduction Lamps

Gaseous Conduction Lamps

Positive Column

High Voltage

1. Script signs of the cold-cathode type. These are in use now throughout practically the entire world, and are described in detail in the succeeding article.

2. This group includes cold-cathode tubes from 1 to 250 ft. in length.

3. Portable unit tubes of the cold-cathode type similar to those in groups 1 and 2.

4. An ordinary incandescent lamp bulb of contemporary form with its filament replaced by a "gas filament" consisting of a fine-bore gas-filled glass tube.

5. Tubes of the ordinary cold-cathode type used in a circuit tuned to resonate at the supply frequency.

Low Voltage

6. Hot-cathode tubes designed to operate on low voltage without a special supply transformer. The electrode in this case is provided with a filament and associated circuit to reduce its potential drop. Tubes of this type can be modified for use on either a-c. or d-c. circuits.

7. Tubes to operate on low voltage without a transformer or other potential-raising device. The main electrode is equipped with a small additional electrode; this electrode provides an electron gap which first functions on low voltage thus causing a long, positive column to form.

8. Similar to group 7 except that bulbs of various sizes are used in place of tubes.

9. Tubes in which the cathode electrode consists of mercury from which is produced the conducting mercury vapor.

10. These are tubes with a cathode consisting of a steel button over which is compressed a heavy oxide coating for electron production, and penetrated by a small hole. These tubes constituted the first vacuum-tube rectifiers.

Negative Glow

High Voltage

11. Tubes containing two parallel light-giving electrodes throughout their entire length.

12. Bulbs with electrodes which when attached to a high-voltage circuit become surrounded with a negative glow.

Low Voltage

13. Tubes with electrodes which shed corona light when attached to low-voltage circuits.

14. Same as group 12 except that the gas content is neon. This is the commonly known "neon lamp" and can be adapted for television work by fitting it with two flat-plate electrodes about 2 in. square separated by a Crooke's dark space (about 0.01 in.).

15. Cylindrical bulbs fitted with two internal cylindrical concentric electrodes. At the center of the inner electrode is a small cavity or crater which fills with an intense negative-glow light which projects itself from the end of the bulb only. The various sizes made require from 0.0001 to about 2.000 amperes.

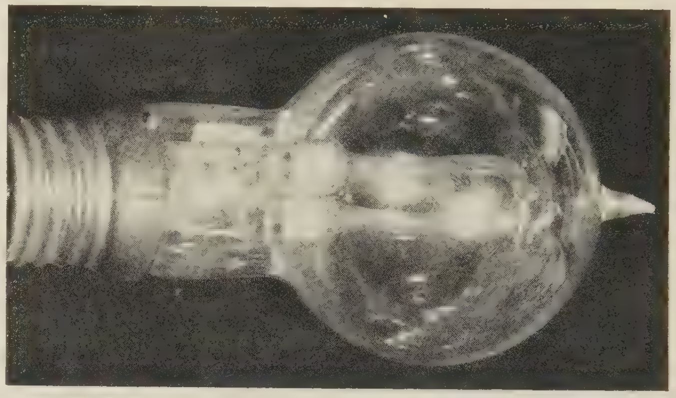
16. A bulb containing two tungsten-filament electrodes placed end to end with only a small space between. The light is due partly to corona glow, partly to incandescent tungsten, and partly to a tungsten arc. Usually these bulbs are charged with neon gas, but sometimes also contain mercury.

nate on a 25,000-cycle inductor generator used as a source of supply.

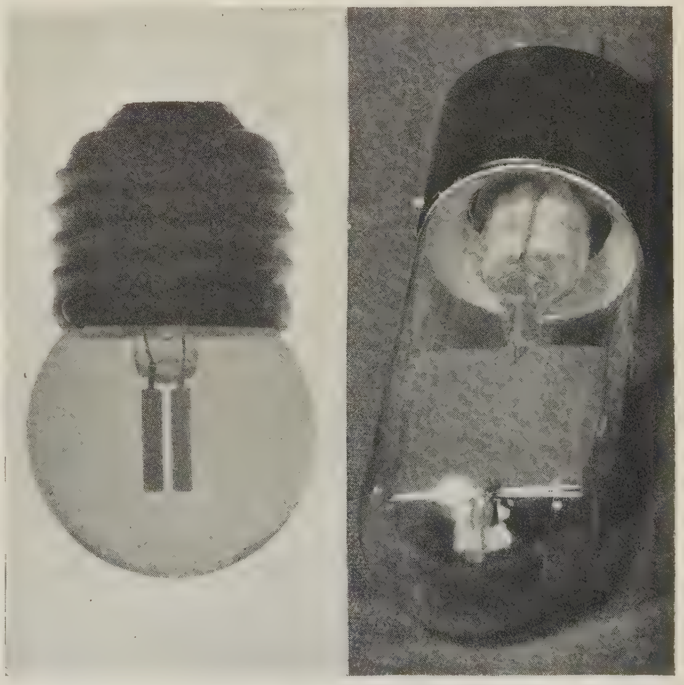
The year 1905 marked an important development in that the first script sign was put into use, and since that time the evolution of this type of light has been particularly rapid. The use in Paris in 1910 of nitrogen in a tube 150 ft. long marked one of these outstanding advances. Neon gas was introduced first into a bulb-type lamp with a gas filament in 1913. The significance of this step is too well known to require any further comment.

In 1915, however, an auto-thermic method of furnishing the carbon-dioxide gas then in common use was brought out; a lamp equipped with this device was said to give a perfect color value. Later this unit was made up with a 100-in. hairpin tube containing neon (exhibited at the New York Electrical Show in 1918) and its luminous efficiency was shown to equal that of the best incandescent lamp then available. Neon has found continued use through later developments right up to the present time not only for sign lighting but also for many of the other types of tubes and bulbs listed in the tabulation.

The future of gaseous tube lighting seems bright



A typical "gas-filament" lamp (group 4). Note that the metal filament is replaced by a fine-bore gas-filled glass tube



Two lamps of group 14. (Right) a television lamp; (left) an ordinary so-called "neon lamp"

because its underlying efficiency, color, and intensity are all better than those possessed by the present solid conductor lamp. In addition manufacturers of solid conductor lamps today are resorting to inside frosting and exterior opalescent glass to increase the area of the light source; the gaseous tube possesses such properties inherently. That electro-luminescence will be "the light of the future," seems assured by recent advances which even now are causing the scientific world to expect still further developments.

Neon Tube Sign Lighting

The high-voltage cold-cathode neon tube as developed for commercial sign lighting is one of the few types of gaseous-conduction lamps to gain prominence. Their operating characteristics and associated transformer equipment are described in this article, and their advantages pointed out.

By
P. A. KOBER
Non-member

Claude Neon National Laboratories, Long Island City, N. Y.

IN THE DEVELOPMENT of neon sign lighting, great difficulties, and not a few, had to be overcome. As in other new developments, when the many obstacles encountered in the laboratory were surmounted, the additional problem of selling this new type of sign lighting to the public presented itself. That both difficulties were overcome is evidenced by the tremendous growth of the industry.

Although neon with its characteristic red glow was the first gas used for this type of lighting, a demand for other colors soon followed. Practically every color now is obtainable by utilizing the characteristic colors of other inert gases in clear glass tubing, and from mixtures of mercury and the inert gases in colored glass tubing.

Commercial neon sign lighting, however, as it is today, would have been delayed greatly had it not been for Georges Claude, a noted scientist of France. The value of his contributions, and particularly his success in the extraction, purification, and production of neon and other inert gases from the atmosphere, cannot be over-estimated.

Nature of Gaseous Discharge

Like the low-voltage gaseous conduction tube, the high-voltage tube belongs to the space-charge type, but differs from the former in that it may have either a positive or negative volt-ampere characteristic. The former is known as the arc; the latter as the glow discharge.

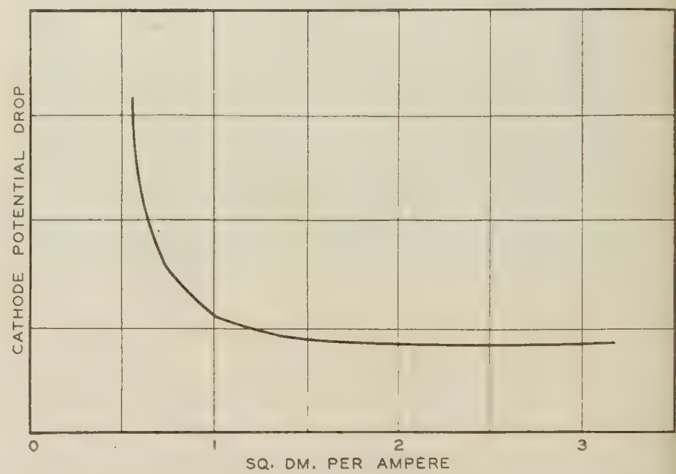


Fig. 1. Minimum cathode-drop characteristic for gaseous glow-discharge as obtained by Claude

No numerical values are given for the ordinate since these vary with different electrodes

In high voltage tubes of this type a high cathode potential drop exists which cannot be neutralized as is done in the hot-cathode type. This results in a certain amount of lost energy from which little or no light is obtained. Furthermore, this high-cathode drop, represented by a space charge consisting mostly of positive ions, tends to produce disintegration of the cathode by virtue of the relatively large mass and high velocity of these positive ions. In order to minimize disintegration by sputtering, and give a long-life tube, current values, electrode sizes, and gas pressures must be determined so as to keep the rate of sputtering sufficiently low; in other words, the mean free path of the positive ions must be decreased as much as other factors will permit, and the current per unit area of cathode must be made as small as possible. Claude has found that when the area of a cathode is in excess of 1.5 sq. dm. per ampere, the cathode drop reaches a minimum value (see Fig. 1).

Further explanation in regard to sputtering or disintegration of electrodes will not be amiss since, barring mechanical or electrical defects, this phenomenon

Written specially for Electrical Engineering and based upon an oral presentation before the Illumination Group of the New York Section, A. I. E. E., March 3, 1931. Not published in pamphlet form.

argely determines the life of the tube. The sputtering of electrode material forms a thin metallic film on the inside of the tube near the electrodes. It is known also that sputtering occludes the gas of the tube and thus diminishes the gas pressure, thereby increasing the mean free path of the positive ions. Since sputtering is caused primarily by the positive ions the net result is a cumulative increase in the tube operating voltage and also in the sputtering effect on the cathode. Finally, the voltage required to operate the tube becomes greater than that supplied by the transformer; at this point the sign begins to flicker and eventually goes out. The tendency to sputter varies with different metals but appears to be related to the latent heat of fusion, specific gravity, affinity for oxygen, and a number of other physical characteristics.

Transformer Characteristics

To operate long tubes of small diameter obviously necessitates the use of a step-up transformer, since for

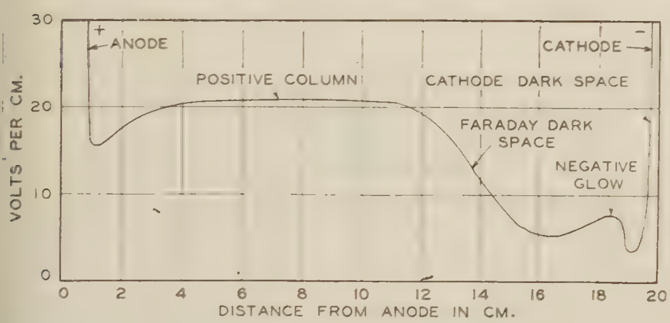


Fig. 2. Potential gradient for typical neon glow-discharge tube

the longest tubes an open circuit potential of about 15 kv. is required. With this high voltage, as might be surmised, many difficulties had to be overcome; principally those concerned with insulation.

Transformers now used are of the shell type, with a magnetic shunt inserted between the primary and secondary coils, to give high leakage reactance. With this arrangement the required qualities of exceptionally good current regulation and poor voltage regulation are obtained. The secondary terminals may be short-circuited without increasing the secondary current to any appreciable extent beyond its normal value. With the balanced-type transformer, which has a grounded center tap on its secondary winding, either high-voltage lead may be grounded without increasing the current (0.028 ampere) above that resulting from a terminal-to-terminal short circuit. Incidentally, this current is only about 0.006 ampere higher than that which constitutes a maximum tube load.

Transformers for commercial neon sign lighting, also must meet rigid specifications in their insulating qualities, and must be able to withstand about four times their maximum secondary operating voltage. This is necessary because in the actual operation of high-voltage tubes, high-frequency transients with high peak voltages sometimes occur and provision for this must be made.

Aside from the transformer, for commercial use the high-voltage cables connecting the secondary terminals to the tube electrodes must pass voltage tests 50 per cent higher than those specified by the board of underwriters. Good insulation between the tube electrodes and the grounded metal housing must be provided also; for this purpose porcelain or glass bushings are used. Owing to metallic dust or moisture accumulation on these parts leakage or brush discharge sometimes occurs at the bushings; however, with the balanced-type transformer used, electrode punctures and strains on cables are reduced greatly, since the maximum voltage between any point and ground is only about half of its former value with the older transformers.

Tube Characteristics

The varying potential gradient of a typical neon glow-discharge tube is illustrated in Fig. 2 while Fig. 3 shows the general shape of the volt-ampere characteristic for a glow discharge. As may be noted, from *A* to *B* the curve has a negative slope. This is due to the fact that the cathode drop remains normal up to point *B* while the voltage of the positive column, having a negative characteristic, decreases with the current. At point *B* (zero slope) the cathode drop becomes abnormal and just balances the positive-column drop. From *B* to *C*, the abnormal cathode drop with an increase in current, increases more rapidly than the positive column decreases; this explains the positive slope.

In Fig. 4 may be seen a curve showing how the volts per ft. of positive column vary with tube diameter;

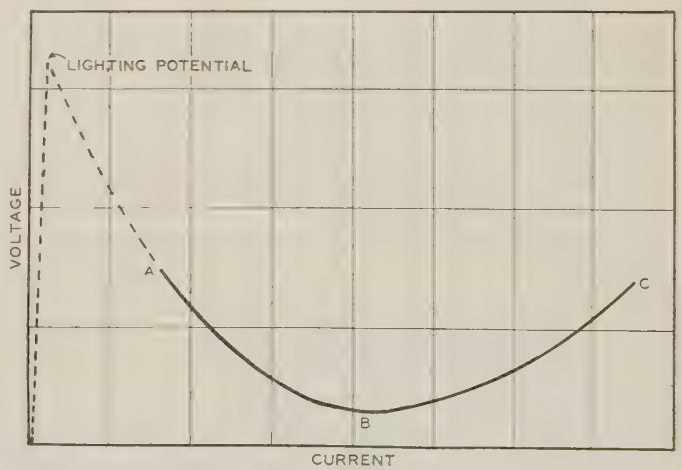


Fig. 3. Ideal volt-ampere characteristic for gaseous glow-discharge

No numerical values are given since these vary with other factors

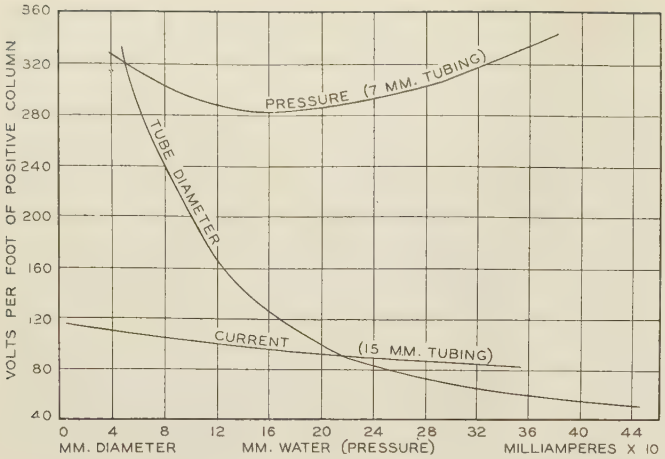


Fig. 4. Curves showing relation between volts per ft. of positive column and tube diameter; also typical curves for gas pressure and current

typical curves for current and gas pressure are given also. In general these will be found self-explanatory. Specifications for a typical neon sign installation are given in Table I. This will serve to summarize some of the points brought out by the discussion and curves.

TABLE I—SPECIFICATIONS FOR A TYPICAL NEON SIGN INSTALLATION

Tube	
Diameter	15 mm.
Length	60 ft. (4 tubes)
Gas	neon
Transformer	
Primary volts	110
Secondary volts (open)	15,000
Secondary volts (with load)	depends on tube length (max. 10.000)
Secondary milliamperes	25
Load watts	210
Volts per ft.	130
Watts per ft.	1.5
Lumens per ft.	36
Lumens per ft.-watt	24
Power factor	0.40 to 0.60
Life	10,000 to 15,000 hr.
Electrode drop per tube	250-300 volts

Colors and Other Developments

As stated in the beginning practically all colors now are being made commercially by the use of the characteristic colors of the inert gases in clear glass tubing, and by the use of mercury and gas mixtures in colored glass tubing. It may be interesting to note here that a more efficient colored light can be produced from the characteristic glow of these various inert gases in clear glass tubing than can be obtained from incandescent lamps and filters. Significant also is the fact that the proper combination of colored tubes provides a true and efficient "daylight white" light source. Finally, an important feature of the light from gaseous conduction tubes is its uniformity of distribution and absence of glare.

Aside from sign lighting, high-voltage tubes are finding application as aviation indicators, beacons, showcase lights and for interior decorative effects. Ordinarily neon sign tubes have not lent themselves to moving effects as readily as have incandescent lamps. However, recent work in producing moving luminous phenomena in the tubes themselves such as moving "beads" and progressive lighting look promising.

The Propagation of Electric Waves

Progress made during the past year in the study of the propagation of electric waves is reported upon briefly by the A. I. E. E. electrophysics committee.

THE YEAR 1931 is the centennial of the discovery of electromagnetic induction by Faraday and by Henry; and also of the birth of Maxwell, the founder of the electromagnetic theory. It is appropriate, therefore, that a contribution of the A. I. E. E. electrophysics committee should deal with the propagation of electric waves.

Man now is employing and controlling electric waves of frequencies ranging from 0 to 10^{21} cycles per sec., but this discussion will portray the year's progress only in the lower portion of this range, for frequencies up to about 3,000,000,000 cycles per sec. Heat, light, and X-rays thus are disregarded.

Electromagnetic Waves Along Conductors

Propagation of electric waves along conductors is of interest to both the communication engineer and the power engineer. To the latter, one of the principal problems is that of the propagation of high-voltage waves, such as those induced by lightning.

Effects of change in circuit constants, effects of corona and other factors, and the changes in potential and in wave shape, all of which occur as such high-voltage

A progress report of the A. I. E. E. electrophysics committee. Not published in pamphlet form.

waves are propagated along power lines, have been studied by means of the portable cathode-ray oscillograph. Effects of change in circuit constants are discussed in a paper by McEachron, Hemstreet, and Seeyle (A. I. E. E. TRANS., Oct. 1930). In general, recent oscillographic tests on the propagation, reflection, and superposition of traveling waves have confirmed the purely theoretical predictions. Extensive oscillographic tests also were made to determine the effect of corona and other factors which decrease the potential and change the wave shape of high-voltage traveling waves. Oscillograms showing the effect of corona upon "artificial lightning" waves were especially important and interesting. These tests are described in a paper by Brune and Eaton at the Rochester A. I. E. E. District meeting April 29-May 2, 1931.

Cathode-ray oscillographic studies of the propagation of traveling waves in the armature windings of generators are described in papers by Boehne, and by Fielder and Beck (A. I. E. E. TRANS., Oct. 1930). The velocity of propagation in this case was found to be of the order of 10,000 mi. per sec. in the slots (Boehne).

Influence of the earth upon the propagation of electromagnetic waves along conductors has been subjected to much study during the year. Evans (*Phys. Rev.*, Vol. 36, p. 1,579, Nov. 15, 1930) has considered the case of a wire parallel to the surface of the earth with the earth itself as return, assuming a conductivity for the top stratum of the ground different from that of the remainder. Ollendorff (*Arch. f. Elekt.*, Vol. 23, p. 261, 1930) has dealt with this problem in considerable detail, being especially concerned with a top stratum of relatively high conductivity. Bowen and Gilkeson (JOURNAL A. I. E. E., Vol. 49, p. 657, Aug. 1930) have described some experimental results on the mutual impedances of ground-return circuits, checking the practical use of the theoretical formulas. Peterson (*Bell Sys. Tech. Jl.*, Vol. 9, p. 760, Oct. 1930) has discussed the transients in a similar case.

RADIO-WAVE PROPAGATION

While no important new discoveries in radio propagation seem to have been reported during the past year, there has been considerable progress in several lines of work which had been started during previous years.

Work with "ultra short" waves having lengths of less than 10 m. or frequencies greater than 3×10^7 cycles per sec., has become one of the major activities in wave propagation. Spurred on by the potential importance of these waves in communication, numerous workers have studied the phenomena qualitatively. Waves of lengths of less than 5 or 6 m. seem never to be reflected from the Kennelly-Heaviside layer. Therefore reception is not subject to fading, the name given to erratic fluctuations which are due to changing conditions in the ionized upper atmosphere and which are a source of considerable difficulty for waves longer than 10 m. However, phenomenally long ranges cannot be obtained. Transmission is best where an unobstructed optical path exists, but owing to the curvature of the earth such paths between points on the earth's surface are limited in length to the order of 100 or 200 mi. While an unobstructed path is best, these short waves will bend around obstacles, presumably by diffraction. As a result, the receiver may be located at points beyond the horizon of the transmitter, although there is a corresponding loss in transmission efficiency.

The extent to which reliance may be placed on diffraction obviously decreases with wavelength. For wavelengths in the order of 20 cm., it has been found, as expected, that an unobstructed path is essential; at any rate with the transmitting and receiving apparatus that has been available.

While an extended list of references cannot be given, the papers by Esau and Hahnemann (*I. R. E*, March, 1930) Jouast, (*L'Onde Electrique*, January, 1930) Ferrié (*Annales des Postes*, April, 1931) and "Micro Ray Wireless"—a new short-wave system demonstrated by I. T. and T. Laboratories, telephony on 18 cm. across the Strait of Dover, (*Electrician*, April 3, 1931) may be cited.

The role of the earth in radio propagation has claimed the attention of many investigators. Rolf (*I. R. E.*, March, 1930) has given curves which are based on Sommerfeld's well-known investigation and which makes this paper more useful to the engineer. Certain limitations in the applicability of these data have been pointed out by Wise (*I. R. E.*, November, 1930). The earth as a reflector of radio waves has been studied by Strutt (*Elek. Nach. Tech.*, February, 1930) Verman (*I. R. E.*, August, 1930) and others.

The Kennelly-Heaviside layer also has held the attention of many of the investigators. One of the more important results obtained has been the corroboration of the double-layer hypothesis advanced by Appleton. In this connection the work of De Mars, Gilliland, and Kendrick (*I. R. E.*, January, 1931) and of Goodall and Schafer (*U. R. S. I.*, May 1, 1931) may be noted. A minimum of effective ionization apparently exists between the heights of 110 km. and 250 km. In this work the echo method has been used to a considerable extent. Cases of relatively long delays due to slow group velocities under certain critical conditions have been observed and these may conceivably have a bearing on the very long delay echoes discovered by Hals and Stormer.

Hanson has presented orally some results on layer heights observed in the Antarctic by the Byrd expedition. It is of interest that even in the long winter night, reflections are obtained, although from greater heights than those found in other latitudes. In general, the phenomena were erratic.

The committee is indebted to K. B. McEachron, of its membership, and to J. C. Schelleng and J. M. Eglin of the Bell Telephone Laboratories, for material for this report.

Airplane Flight Aided by Electricity

Electrical instruments by giving accurate and reliable indications of direction, altitude, and of operating, traffic, and weather conditions, are contributing to safe flight even in dense fogs. Liberal use of instruments now available and development work along the line of new devices, are hastening the time when air transportation will compare favorably with other types.

By
C. F. GREEN
Non-member

General Electric Co.
Schenectady, N. Y.

AIR TRANSPORTATION in this country has witnessed remarkable growth. In a four-year period the ton mileage for mail and express transportation has been multiplied by 11 while passenger mileage over regular routes has been multiplied by 110. Other flying activities also have shown commensurate gains. Although regularity of service has increased, further progress is in order, for only when schedules can be maintained safely and on a basis comparable with other forms of transportation will the general public come to accept and depend upon air transportation. In this connection, however, it must be borne in mind that even the older forms of transportation are limited by many of the factors influencing air transportation. Railway trains still are delayed by fog and storm, and sea navigation with all its intensive development has not arrived yet at the point where an ocean liner can be brought into harbor in a dense fog and docked.

Up to the present time safety has been secured largely by the long experience and skill of the pilot. One of the greatest changes in the history of piloting however now is taking place as regards the pilot's attitude toward instruments and means of communication and traffic control. A pilot need no longer be without the aid either of instruments or ground personnel during flight.

In order that regularly scheduled flights may be established there are needed:

1. Means for keeping on the course (whether fixed or varied with weather or traffic conditions).
2. Means for checking operating conditions of engines and other equipment.
3. Means for communication enroute as well as at the terminals.
4. Aids for making a safe landing even in fog.

Means for Keeping on the Course

To stay on the course during the most severe weather conditions the pilot must find his way without sight of ground or beacon lights along the airway. Under such conditions he must rely solely upon instruments for direction since his senses then are inadequate and may be dangerously misleading.

For directional indication the pilot must depend upon compass indications. While a small magnetic or card compass fulfils minimum requirements, for accurate and reliable indication the magneto compass has been developed. This instrument is a remote-indicating device utilizing the horizontal component of the earth's field; it is an outgrowth of the earlier earth inductor compass. The generating unit in this instrument is mounted in some part of the plane which is relatively free from distorting magnetic influences, and is driven either by a wind rotor or by an electric motor supplied from the plane's battery. Two permalloy pole pieces are mounted so as to concentrate the earth's field through the armature. Normally the two pole pieces are held in an East-West direction by a course-setting mechanism located within easy reach of the pilot; when in this position no magnetic field is impressed upon the rotating armature. Any change in the direction of flight which will shift the pole pieces from an East-West position brings the permalloy bars under the influence of the horizontal component of the earth's field. Thus a current is generated which shows by means of a conveniently located indicator, deviation to right or left from the determined course. The pole pieces are maintained in a horizontal position by means of a pendulum which is either liquid or air-damped.

All magnetic compasses are subject to errors when accelerations occur which permit the vertical component of the earth's field to influence the sensitive element. To overcome this the turn compensator has been developed. This device employs an electric gyro element, by means of which a potential is impressed upon the magneto compass circuit which bucks the compass potential caused by the acceleration or turn.

In addition to its use as turn compensator, the gyro element may be used independently as turn indicator to aid in maintaining a straight flight. A separate indicator is provided for this use being connected in the same circuit as the turn compensator. A turn indicator obviously is one of the most important instruments

From "Electrical Solutions of Problems of Regular Scheduled Flight," (**No. 31-M3**) to be presented at the A. I. E. E. Pacific Coast convention, Lake Tahoe, Calif., Aug. 25-28, 1931.

used in blind flying and accordingly much development work has been done to make it reliable.

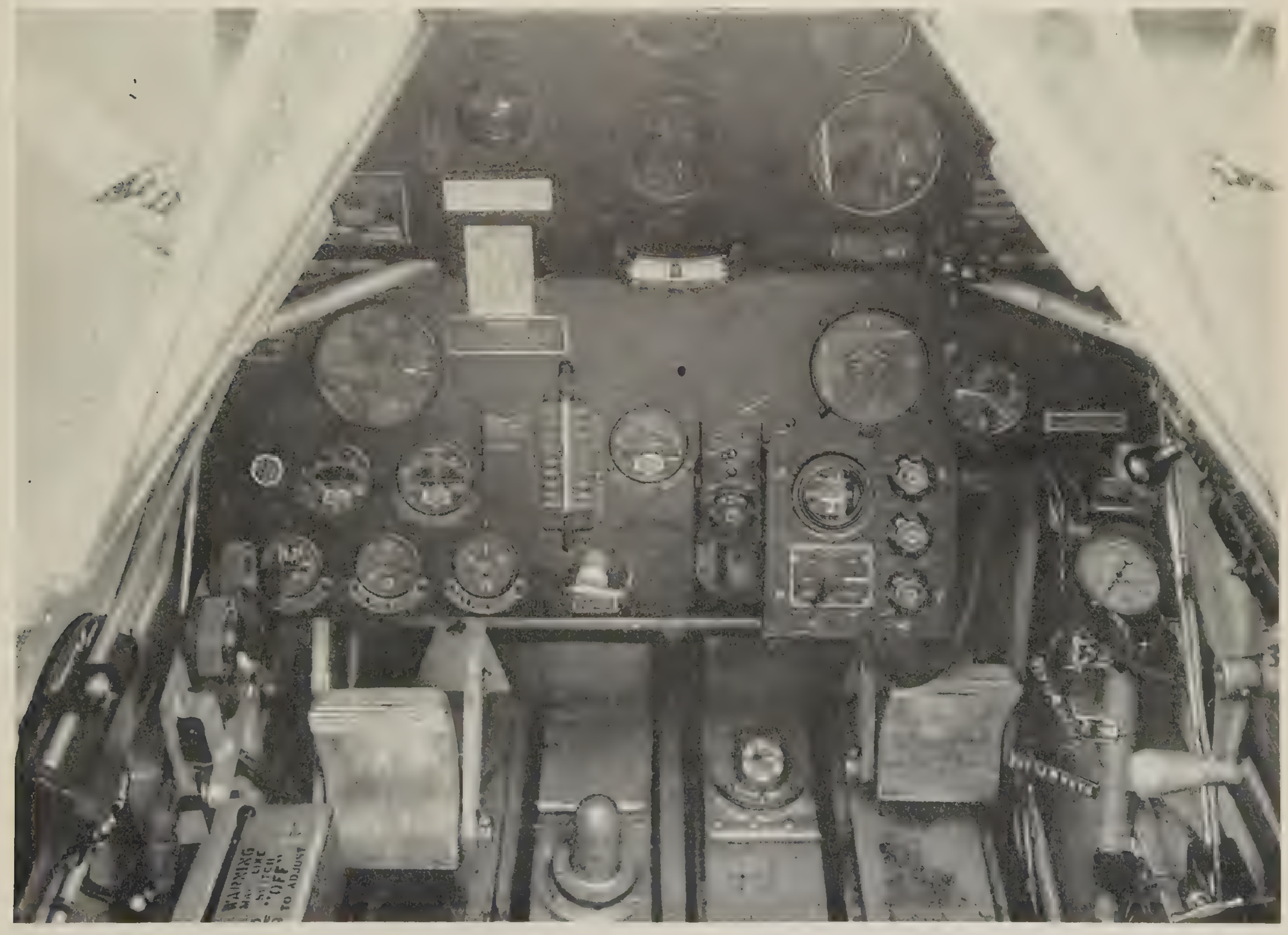
Automatic Control

Various forms of automatic control have been experimented with for many years, and development is proceeding in all countries to free the pilot from strain and permit him to devote his attention to "avigational" and other matters. One such arrangement has been developed utilizing the magneto compass as the direction-sensitive element and turn compensator as the turn-sensitive element. With this arrangement the magneto compass lays down a definite base line and the turn compensator maintains correct indications during accelerations and turns. A sensitive polarized relay replaces or is used in combination with the compass indicator and through a vacuum-tube circuit, controls two magnetic clutches of an electric steering mechanism. A follow-up system provides for deflection of the rudder from a chosen neutral position proportional to the departure of the craft from the course. The accuracy with which a course may be followed with the aid of this arrangement is remarkably good.

Radio Beacons

To be able to fly a straight course blindly is of little advantage, however, unless the aircraft reaches its destination, and no matter how accurate the instruments aboard the plane may be they do not indicate drifting due to winds. Radio has been found useful in this connection in that it furnishes the aviator with reference points or axes. Two general classes of equipment in use are (1) course beacons and (2) direction finding apparatus. In this country the first class is employed almost exclusively along the airways, the two types in general use being respectively aural and visual beacons. The aural type transmits a code signal alternately from two loops thus providing for four courses at each beacon. The listening pilot hears a *dash-dot* or a *dot-dash* signal when off course, depending upon his direction from the course, and a series of long dashes separated by the station's identifying signals when on course.

With the visual type of beacon, the interlocking signal system is replaced by one employing two modulation frequencies which are received with equal intensity when on course and with unequal intensity



Interior view of a typical airplane cockpit showing the multiplicity of instruments to assist the pilot in maintaining safe flight

when off the course. While visual indicators employing tuned reeds sometimes are used, pointer-type indicators possessing certain advantages over the reed indicators have been developed.

For flying off the established airways a homing device adaptor has been developed for standard aircraft receivers. This is used with a fixed wing loop and indicates by a meter on the instrument panel whether the plane is on or off course directly toward the station tuned in. Since this device uses the ordinary broadcast wave band as well as that of the beacons, the plane may be directed at any broadcasting station within range; tests have shown that in general a pilot can fly toward a powerful broadcasting station from a distance of about 200 mi.

Altimeters

Among other indications the pilot is vitally concerned in knowing his height above the terrain over which he is flying. Elevation above the starting point is given by a barometric altimeter which is included in the normal equipment of any plane, but inadequate over rough country. The radio altimeter is one of the three general types of instruments which have been developed to solve this difficulty. Operation of this device is based upon the principle that if a radio wave is radiated from an antenna and reflected back to the source by a large, conducting mass, the change in the antenna characteristics will result from the combined outgoing and reflected waves. While this device does not give positive indications at elevations of less than 350 ft., indications of high accuracy may be obtained at altitudes of 650 ft. or more.

Means of Checking Operating Conditions

Flight and avigation instruments must be supplemented by other instruments showing engine and atmospheric conditions, and general operation of the plane. Here is a wide field for remote electrical indication as multi-motor planes find increased application to transport service. Some of the instruments of this type which have been developed include engine tachometers, oil- and fuel-pressure gages, oil- and water-temperature indicators, and cylinder-temperature indicators. Although recently many different types of these electrical instruments have received publicity, they consist principally of instruments already standardized for other uses, but adapted to meet the special needs of the airplane. The remote indicating features of these instruments make their installation extremely simple as compared with present equipment with its long lengths of tubing and flexible shafting.

Means of Communication

A radio beacon may serve to keep a pilot on his course but it does not inform him of conditions along the airway. For this purpose, radio telephone rather than telegraph has been chosen by the majority of transport operators. Now, the pilot under this guidance is in an entirely different situation than a few years ago. Instead of flying into unknown and shifting weather conditions single-handed and without accurate information, he has available many contacts through his own radio equipment. In addition, traffic control at all times during flight has made possible an increase in the safety of landing under conditions of low ceiling and poor visibility.

Aids for Landing

Safe landing on a fog-bound terminal remains the great problem confronting air transportation. In general, transport companies avoid any possibility of being forced to land in a fog in the same way that all ocean liners meet their corresponding problem. However, organizations now are making strenuous efforts to make safe the blind landing of a plane, and here it is that radio, light, sound, and all other agencies are needed, for each may contribute to the solution. It is through a coordinated system that ultimate success may be hoped for.

Blind landing requires the guidance of the plane from the beacon course, or course determined by direction finding, to an approach course at the airport. In addition, the runway position must be determined; the pilot also must know his height above ground and traffic conditions about the port. Radio plays an important part in directing the plane to the field, in indicating the field boundaries and in providing the pilot with means of communicating with the ground personnel.

Light also furnishes some aid for night flying under conditions of low visibility; however, due to scattering of the light by the fog particles ordinary boundary lighting and floodlighting are of little avail for fog landings. Consequently lighting cannot be considered of much aid under such conditions unless modulated light or intense flashes are available.

Sonic Altimeter

For height-above-ground indications in landing, the sonic altimeter is especially adapted. As in depth sounding, sound waves reflected from the ground are utilized. From a compressed-air whistle mounted in a megaphone which directs the signals downward from the aircraft short blasts are blown automatically at brief intervals. The echo of the outgoing signal is received in a second megaphone which is connected through a high-pass acoustical filter to a stethoscope worn by the pilot. A timing device mounted on the instrument panel indicates altitude, this indicator being calibrated directly in feet. As the distance above ground decreases, the interval between the two signals

naturally decreases also; experience has shown that when the outgoing signal and echo appear to blend, the plane is at an altitude of about 5 ft. or less.

So varied are conditions under which air transport is carried out that no single arrangement can be said to be best. A system which will fit most satisfactorily into local conditions should be adopted. Whatever method is ultimately used, however, must fulfil the requirements of simplicity, lightness, and reliability.

In conclusion it is quite safe to say that, through the use of sensitive and accurate instruments, safe and regular flights can be established in so far as avigational problems are concerned. Further development work along this line together with the added experience of operators, are hastening the time at which this service will assume a position comparable to other forms of transportation.

Desirable Accuracies in Instrument Transformers

Errors in both the producer's total meter registrations and the consumer's single meter registration are analyzed and evaluated by the "probable error" method. Accuracies better than 0.5 per cent are shown to be valueless from a practical standpoint.

By
E. C. WENTZ
Associate A. I. E. E.

Westinghouse Elec. & Mfg. Co., Sharon, Pa.

HOW MUCH SHOULD BE PAID for increased accuracy in instrument transformers? Are power companies seeking accuracies out of proportion to the returns therefrom? Upon these and other important questions related to instrument transformer accuracy the author has attempted to shed some light. As a result of his detailed analysis he has concluded that with normal metering burdens, accuracies better than 0.5 per cent are valueless commercially. It is shown also that accuracies better than 0.5 per cent seldom can be guaranteed, and thus are of no practical value except as they may indicate that the apparatus may be overloaded safely, or that the guarantee has a larger factor of safety.

It is well known that errors in either current or voltage transformers may be decreased by increasing the cross-section of either the copper or the iron. This, however, will inevitably increase the cost of the transformer. The problem then becomes one of analyzing the errors present in the conventional type of instrument transformer and evaluating these from an economic standpoint.

If the transformers in question are used in conjunction with a watthour meter, the aggregate error in meter registration will be due to errors in (1) the voltage transformer, (2) the current transformer, and (3) the watthour meter.

The error introduced by the voltage transformer is usually a constant quantity which can be obtained either by measurement or from a calibration curve. This remains constant so long as the burden and line voltage are constant.

Errors introduced by the current transformer may be shown to vary with the line current (see Fig. 1). This variation may be measured, or obtained from a calibration curve. However, meter registration errors due to the current transformer depend also upon the load cycle and load power factor, as may be noted from Fig. 1. The net effect is that in general the combined errors will be such as to make any meter to which the transformer may be connected, run fast at full current and slow at light currents, although this condition is sometimes reversed at very low-line power factor.

Similar variation exists in the errors introduced by the watthour meter; and the same difficulty will be encountered in estimating the error in total meter registration. A curve showing typical watthour-meter error is given in Fig. 2.

To determine the magnitude of error in total meter registration in terms of the errors in the current transformer and watthour meter is not strictly possible without a vast amount of work involving among other things a record of the load cycle. A relation may be approximated, however, by the introduction of what will be called the "probable error." The idea of a "probable error" is familiar to most engineers, but as used in this particular problem may be defined in the following manner: Each current transformer and each meter introduces an uncertain error into the total watthour-meter registration. This error is uncertain because of its dependence upon the load cycle and other variable factors; its most probable magnitude, however, is designated as the "probable error" and may either add or subtract from the true readings.

An exact determination, or even an estimation of the probable error due to the current transformer, is impossible. However, the probable error will not be greater than the maximum ratio error over the range from 10 to 100 per cent current. This assumption is of course empirical; it is based on the fact that with most current transformers and usual load power

Written especially for ELECTRICAL ENGINEERING. Not published in pamphlet form.

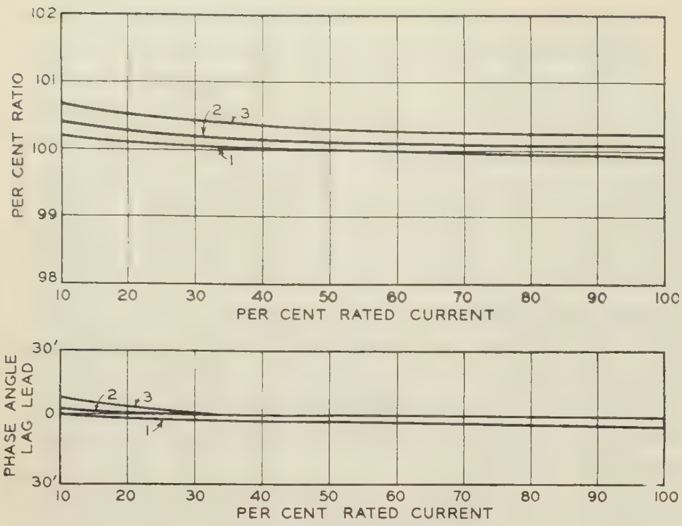


Fig. 1. Ratio and phase-angle curves for typical current transformer

1. 2.5 voltamperes, 0.90 power factor
2. 15 voltamperes, 0.90 power factor
3. 50 voltamperes, 0.50 power factor

factors the maximum error in wattmeter indication does not differ greatly from the maximum transformer-ratio error.

It is conservative to assume the maximum error to be the probable error in registration. Accordingly, this assumption will lead to a pessimistic conclusion, the actual errors being less than predicted by this analysis. This point should be kept in mind following through the rest of the argument.

Probable Error for Producer

A typical three-phase metering installation will involve two current transformers, two voltage transformers, and a watthour meter containing two elements. As already pointed out, the voltage-transformer error usually is constant and may be eliminated.

If the current transformer introduces a probable error of P_1 per cent, and one watthour-meter element an error of P_2 per cent, the total probable error of the combination is $\sqrt{P_1^2 + P_2^2}$ as these errors multiply or divide (see any college physics laboratory manual for combination of probable errors). The error of the combination in the other phase also is $\sqrt{P_1^2 + P_2^2}$. The most probable correct power reading will be the registration of the meter, and the probable aggregate error in this registration will be

$$\sqrt{\frac{P_1^2 + P_2^2}{2}}$$

as the errors in the two phases add or subtract.

In a large power system there will be n such installations, each introducing the same probable error. Therefore the total probable error for the entire system will be

$$\sqrt{\frac{P_1^2 + P_2^2}{2\,n}}.$$

These expressions indicate the following:

1. It is of little use to reduce one of the errors P_1 or P_2 unless the other is reduced correspondingly. The magnitude of P_1 and P_2 logically should be the same.

2. If n is large enough, the probable error in the individual installation may be objectionably large without causing the probable error in the grand total of all the registrations to be worthy of consideration.

The accuracy of the total registration, which it should be remembered represents the total income of the producer, is insured then by the mere number of meters in a large system, whether or not exceptionally accurate metering apparatus is installed.

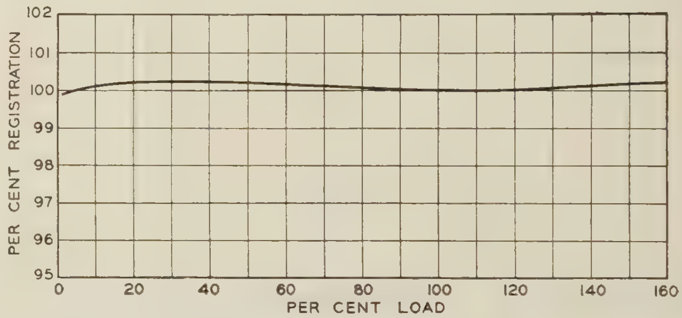


Fig. 2. Load-registration curve for a typical watthour meter

Probable Error for Consumer

To extend the idea of probable error to find the error in the total expenses of a given consumer, it must first be considered that one meter registration generally represents only a small part of any consumer's total expenses. If each of n commodities making up the major part of a consumer's purchased supplies are measured with a probable error of P_1 per cent, the resultant probable error in his total commodity bill will be

$$\sqrt{\frac{P_1}{n}}$$

(assuming the various items to be equal in amount). If one of these individual errors P_1 could be reduced to zero, the probable aggregate error in the bills for the remaining $n - 1$ items would be

$$\sqrt{\frac{P_1}{n-1}},$$

and in per cent of the total bill would be

$$\sqrt{\frac{P_1}{n-1}}\left(\frac{n-1}{n}\right).$$

Reducing one probable error to zero then would reduce the total resultant error from

$$\sqrt{\frac{P_1}{n}} \text{ to } \sqrt{\frac{P_1}{n}}\sqrt{\frac{n-1}{n}}.$$

To reduce the probable error in the measurement of one commodity only, is obviously of negligible benefit. It is evident also that the probable errors in the measurement of the various commodities logically should be the same.

Commodities purchased by weight are weighed on a scale with a probable error of perhaps 0.5 per cent, as the scales ordinarily are used; commodities purchased by volume are measured or metered to within perhaps 0.5 per cent also. It would seem, then, that unless electric power is by far the largest commodity purchased, it will be impractical to meter it to an accuracy better than that attained in the measurement of other commodities supplied.

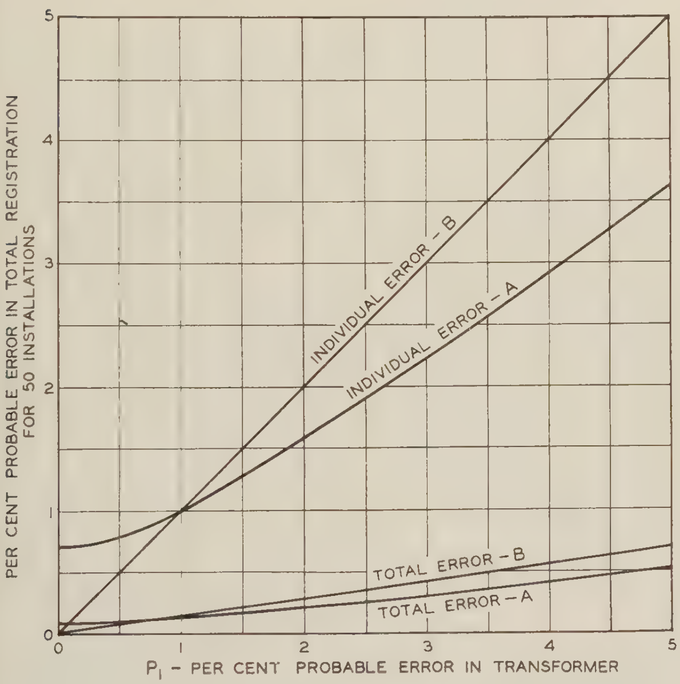


Fig. 3. Probable error in registration for different current-transformer and watthour-meter errors

P_1 = probable error in current transformer
P_2 = probable error in watthour meter element
A. P_2 constant at 1 per cent
B. $P_2 = P_1$

To return to the expressions for probable error in meter registration, and to consider numerical examples:

$$\text{Individual probable error} = \sqrt{\frac{P_1^2 + P_2^2}{2}}$$

$$\text{Total probable error} = \sqrt{\frac{P_1^2 + P_2^2}{2n}}$$

If $P_1 = P_2 = 1$ per cent
and $n = 20$, (a small number)
the probable errors are

$$\sqrt{\frac{P_1^2 + P_2^2}{2}} = 1 \text{ per cent for the individual}$$

$$\sqrt{\frac{P_1^2 + P_2^2}{2n}} = 0.22 \text{ per cent for the total.}$$

If $P_1 = P_2 = 0.5$ per cent and $n = 50$ (a more usual case) the probable error will be 0.5 per cent for the individual but only 0.07 per cent for the total. This aggregate error of 0.07 per cent is within the limits of precision accuracy; still 0.5 per cent represents a reasonable accuracy which may be expected in most cases.

From the foregoing it may be seen that the resultant probable error decreases in the same proportion as do the errors P_1 and P_2. If the probable individual error and the probable total error in meter registration are plotted against P_1, assuming P_2 to remain constant at 1 per cent, curves *A*, Fig. 3 are obtained. If $P_1 = P_2$, curves *B* result as P_1 and P_2 vary together. The curves *A* show that if $P_2 = 1$ per cent, it does little good to reduce P_1 below 1 per cent, since reducing it to zero reduces the total error to only 0.71 per cent.

As a final conclusion it appears a well established fact that no certain advantage is to be expected from more accurate metering apparatus than now is available. That accuracy better than 0.5 per cent in a meter or current transformer is of no commercial advantage has been amply demonstrated. Furthermore, this conclusion is supported by the fact that current transformer errors cannot be measured with present commercial testing apparatus with much better accuracy than 0.1 per cent in ratio and 5 min. in phase angle. Consequently, attempts to meet accuracies of better than 0.5 per cent generally result in arguments which never are settled satisfactorily.

Konel—

A Substitute for Platinum

A MAN set out to find a cheap substitute for platinum. He was so successful that for almost a year his results were not taken seriously.

Oxide-coated filament for radio tubes was known as early as 1904; platinum as a core appeared to be the best material for life, strength, and emission of electrons.

From *Research Narratives*, May 15, 1931, published by the Engineering Foundation, 29 W. 39th Street, New York, N. Y. Based on information supplied by Erwin Foster Lowry, Ph. D., research physicist, Westinghouse research laboratory, East Pittsburgh, Pennsylvania.

In 1925, five years after radio broadcasting had aroused public imagination, tubes were being made in ever-increasing quantities with platinum or platinum-iridium core filament. Platinum people were overjoyed, but not makers of tubes. Material for filaments was costing $186 an ounce.

Dr. E. F. Lowry, research physicist of the Westinghouse research laboratory, undertook a search for a cheaper substitute. Iron, nickel, nichrome, tungsten, various ferrous alloys already were pronounced worthless. All had a poisonous effect on emission or had proved mechanically weak. But nickel looked good to Lowry in spite of its reputed mechanical frailty.

The first filament of pure nickel gave surprising results. Emission appeared to be as good as with platinum cores; no more trouble arose from mechanical failures. Scientists, tube manufacturers, even colleagues, hesitated to believe that the first attempt had succeeded when hitherto undisputed authority had pronounced nickel no better than other metals. Against claims that nickel filaments should have a life of only 80 hr., Lowry produced tubes on life tests for 1,500 hr. and still burning. But none of his nickel filaments were manufactured commercially.

Convinced that he was working in the right direction he tried 20 per cent cobalt; the crystalline structure was unsatisfactory and could not be drawn. The case looked hopeless when he thought of the qualities of cobalt-ferrotitanium (a compound of iron and titanium) wire used in experiments several years previously. The first filament of nickel, cobalt, and ferrotitanium, in proportion of 80, 20, and 10, gave results better than ever before. Hundreds of experiments have since been made, but the alloy used today is essentially the same as that produced by Lowry's first attempt.

He named the new metal "konel," and in December 1926 persuaded the Westinghouse Lamp Company to make 50 commercial tubes with it as filament core. About the same time, the manufacturers discovered that Lowry was right also about nickel and started to use that for filaments. Within a year every manufacturer ceased the use of platinum in radio tubes, and none has used it since. Platinum-iridium cost $1,600 per lb.; konel costs a few dollars.

Use of konel not only appreciably increased tube life (operating 175 deg. colder than platinum filament), but also showed definitely that the filament core had a marked influence on emission. A new theory of electron emission from oxide filaments has been formulated; on this work the discoverer is now engaged.

Konel is harder to forge than high-speed steel and is very tough at high temperatures, when most metals lose their strength. It is extremely resistant to most acids, does not sputter, does not scale like iron under heat, and has a high electrical resistance. These unusual characteristics give promise of many uses outside radio tubes. It is an electric furnace product of extreme purity.

Mutual Impedance of Grounded Wires

A formula is given for the mutual impedance between two insulated wires of negligible diameter lying on the surface of the earth and grounded at their end-points.

By
R. M. FOSTER
Member A. I. E. E.
American Tel. & Tel. Co., New York

WE ASSUME the earth to be flat, semi-infinite in extent, of unit permeability, of negligible dielectric constant, and of uniform conductivity λ, using c. g. s. electromagnetic units. The air is also assumed to be of unit permeability and of negligible dielectric constant. All displacement currents are thus neglected both in the earth and in the air. This is the assumption which is ordinarily made as a first approximation at power frequencies for the shorter transmission lines.

The mutual impedance between circuits consisting of insulated wires of negligible diameter lying on the surface of the earth and grounded at their end-points is then found to be

$$Z_{12} = \frac{1}{2\pi\lambda} \int\int \left\{ \frac{d^2}{d\,S\,d\,s}\left(\frac{1}{r}\right) + \frac{\cos\epsilon}{r^3}\left[1 - (1+\gamma r)\,e^{-\gamma r}\right] \right\} d\,S\,d\,s \quad (1)$$

The integrations are extended over the two wires S and s, their elements $d\,S$ and $d\,s$ being separated by the distance r and making the angle ϵ with each other. In this formula $\gamma = (i\,4\,\pi\,\lambda\,\omega)^{1/2}$ is the propagation constant in the earth for plane waves which vary with the time as $e^{i\omega t}$, where $\omega = 2\,\pi$ times the frequency and $i = (-1)^{1/2}$.

This mutual impedance formula (1) may be written in the equivalent form

$$Z_{12} = \int\int \left[\frac{1}{2\pi\lambda} \cdot \frac{d^2}{d\,S\,d\,s}\left(\frac{1}{r}\right) + i\omega\frac{\cos\epsilon}{r}\left\{\frac{2}{(\gamma r)^2}\left[1-(1+\gamma r)e^{-\gamma r}\right]\right\} \right] d\,S\,d\,s \quad (2)$$

The complex factor

$$\frac{2}{(\gamma r)^2}\left[1 - (1+\gamma r)\,e^{-\gamma r}\right] \quad (3)$$

From "Mutual Impedance of Grounded Wires Lying on the Surface of the Earth," *Bell System Technical Journal*, July 1931.

approaches unity as ω approaches zero, and Z_{12} then agrees with the d-c. mutual impedance as given by G. A. Campbell.[1] Introducing this factor (which is a function of γr only) into the reactance term for the d-c. mutual impedance between two elements $d S$ and $d s$ gives the general expression for their mutual impedance corresponding to the propagation constant γ. The variation of the complex factor (3) for increasing values of γr is shown very clearly in the figure, where the real and imaginary parts of (3) are plotted for increasing values of $r' = |\gamma r| = (4 \pi \lambda \omega)^{1/2} r$. The real part, it may be noted decreases rapidly from the initial value unity as r' increases, while the imaginary part is always negative, decreasing from zero to a minimum value (approximately -0.3 for $r' = 1.5$) and then increasing towards zero, although it does not approach zero so rapidly as does the real part.

The first three terms in the expansion of Z_{12} for low frequencies are given by

$$Z_{12} = \frac{1}{2 \pi \lambda} \left(\frac{1}{A a} - \frac{1}{A b} - \frac{1}{B a} + \frac{1}{B b} \right)$$

$$+ i \omega N_{Ss} + (1-i) \frac{1}{3} (8 \pi \lambda \omega^3)^{1/2} A B a b \cos \theta + \ldots, \tag{4}$$

where N_{Ss} is the mutual Neumann integral between the two wires S and s of arbitrary form but with end-points A, B and a, b respectively; θ is the angle between the straight lines $A B$ and $a b$. The first two terms in this expansion are precisely the d-c. mutual impedance as given by G. A. Campbell.

The first term in the expansion of Z_{12} for a long straight wire S and any wire s located near the midpoint of S is

$$\int \left[\frac{1}{\pi \lambda x^2} - \frac{\gamma}{\pi \lambda x} K_1 (\gamma x) \right] \cos \epsilon \, d s, \tag{5}$$

x being the positive distance from $d s$ to S, and ϵ the angle between $d s$ and S.

$$K_1 (z) = - \frac{1}{2} \pi H_1^{(1)} (i z)$$

is the Bessel function of the second kind for imaginary argument as defined by G. N. Watson.[2]

The expression in square brackets in (5) is the mutual-impedance gradient, parallel to an infinite wire at a positive distance x from the wire. It agrees with the results published independently by F. Pollaczek,[3] J. R. Carson,[4] and G. Haberland,[5] and has been employed to obtain numerical results since 1917. Pollaczek has also investigated the case of two grounded circuits of finite length.[6]

The mutual impedance $d Z_{12}$ between a short, grounded circuit $d S$ and a counterclockwise small loop of area $d a$, on the surface of the earth, may be found by applying Stoke's theorem to formula (1), obtaining

$$d Z_{12} = \frac{d S \, d a}{2 \pi \lambda} \cdot \frac{\sin \phi}{r^4} \left[3 - (3 + 3 \gamma r + \gamma^2 r^2) e^{-\gamma r} \right], \tag{6}$$

where ϕ is the angle which $d S$ makes with r, the line from $d a$ to $d S$.

By a further application of Stoke's theorem we may obtain the mutual impedance between two counterclockwise small loops $d A$ and $d a$; namely,

$$d Z_{12} = \frac{d A \, d a}{2 \pi \lambda} \cdot \frac{1}{r^5} \left[(9 + 9 \gamma r + 4 \gamma^2 r^2 + \gamma^3 r^3) e^{-\gamma r} - 9 \right]. \tag{7}$$

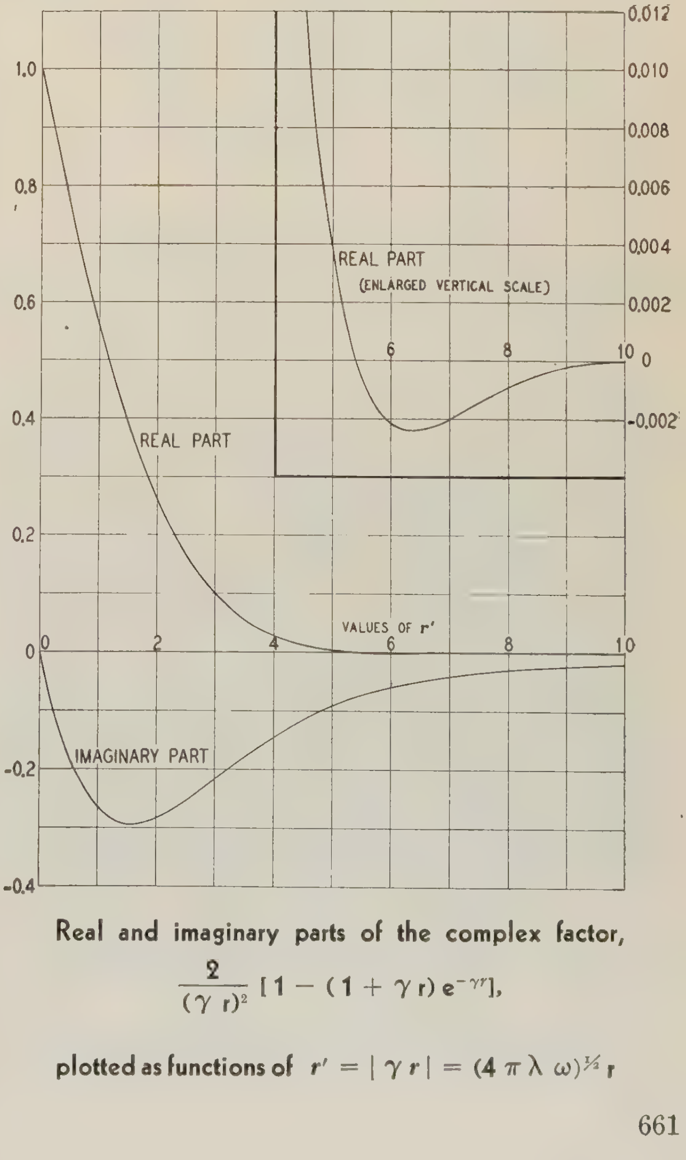
1. For numbered references see bibliography.

Bibliography

1. Mutual Impedances of Grounded Circuits, by G. A. Campbell, *Bell System Technical Journal*, 2, October 1923, pp. 1-30.

2. Theory of Bessel Functions, by G. N. Watson, Cambridge, 1922, pp. 77-78.

3. Uber das Feld einer unendlich langen wechselstromdurchflossenen Einfachleitung, *Elektrische Nachrichten-technik*, 3, September 1926, pp. 339-359.



Real and imaginary parts of the complex factor,

$$\frac{2}{(\gamma r)^2} [1 - (1 + \gamma r) e^{-\gamma r}],$$

plotted as functions of $r' = |\gamma r| = (4 \pi \lambda \omega)^{1/2} r$

4. Wave Propagation in Overhead Wires with Ground Return, by J. R. Carson, *Bell System Technical Journal*, 5, October 1926, pp. 539-554.

5. Theorie der Leitung von Wechselstrom durch die Erde, by G. Haberland, *Zeitschrift fur angewandte Mathematik und Mechanik*, 6, October 1926, pp. 366-379.

6. Gegenseitige Induktion zwischen Wechselstromfreileitungen von endlicher Lange, by F. Pollaczek, *Annalen der Physik*, (4), 87, December 1928, pp. 965-999. His assumptions regarding conditions at the ground connections seem to depart considerably from the conditions assumed in the present paper, and moreover his results are not expressed in convenient form for direct comparison with the formula given above for Z_{12}.

Burn-Off Tests in Low-Voltage Networks

By
GEORGE SUTHERLAND and D. S. MacCORKLE
Fellow A. I. E. E. Associate A. I. E. E.
New York & Queens Elec. Lt. & Pwr. Co., Flushing, N. Y.

An extensive series of tests on standard and experimental cables installed in accordance with standard accepted practise for a-c. low-voltage underground networks, are outlined in this article. Results obtained are useful not only in determining mains-conductor size and network-transformer spacing, but also for indicating desirable future developments in cables for this service.

Fault in single-conductor buried cables cleared in 40 sec. at initial location; total current—5,800 amperes

It is recognized generally that one of the most essential requirements to be met in the operation of a-c. low-voltage networks is the ability of the system to burn faults clear in the underground cables automatically. The purpose of the present study was to determine the characteristics of fault clearance in such networks, tests having been made on both standard and experimental cables.

Faults in cables may be classified with respect to their ability to dissipate the heat generated as, (1) a fault having a thermal capacity less than that of the cable conductors, and (2) a fault having a thermal capacity greater than that of the cable conductors. The clearance of a fault of the first class depends therefore upon the destruction of the fault itself or a progression of the fault and the subsequent burning clear of the cable conductors at a location remote from that of the initial fault; the clearance of a fault of the second class depends upon the fusing of the cable conductors joining the fault.

Nearly all operating experience in low-voltage a-c. network systems has been with rubber- or paper-insulated lead-covered cables. Both operating and previous test data have shown that all ground faults between the conductor and lead sheath have cleared. Tests made (*Low-Voltage A-C. Networks of the Standard Gas and Electric Company's Properties*, by R. M. Stanley and C. T. Sinclair, A. I. E. E. Trans., Vol. 49, p. 278) have indicated also that a minimum of 5,000 amperes is required to clear faults in 500,000-cir. mil cables and a minimum of 3,500 amperes to clear faults in 250,000-cir. mil cables.

Equipment and Tests

The test set-up consisted of 4,000/230-volt network transformers, current-limiting devices, and instruments for voltage and current indications. The transformers were supplied with 60-cycle power from an isolated substation bus section, and were connected so that a 900-kva. capacity supplied power to each side of the fault in the test cable connected in the low-voltage circuit. Both experimental and standard cables were installed

From "Burn-Off Characteristics of A-C. Low-Voltage Network Cables," (**No. 31-66**) presented at the Middle Eastern District meeting of the A. I. E. E., Pittsburgh, Pa., March 11-13, 1931.

for test under conditions simulating present underground-network constructions. A total of 86 burn-off tests was made. Two types of multiple-conductor buried non-magnetic sheath cables were tested, each cable containing three No. 4/0 phase conductors, one No. 2/0 neutral conductor, and one No. 6 conductor which would be required in an actual system layout for multiple street lights. Tests were made also on eight types of single-conductor No. 4/0 buried non-magnetic-sheath cables; four types of No. 4/0 non-metallic-sheath cables for duct installation; and one each of No. 4/0 rubber-insulated, 350,000-cir. mil and 500,000-cir. mil paper-insulated lead-covered cables. In addition to these, two tests were made on No. 4/0 bare conductors, spaced and buried in relatively dry soil.

In general, the tests included a wide variety of faults, the insulation and coverings of the cable in most cases being stripped for a length of approximately six inches from the conductors to be short-circuited; the conductors were then forced together for a length of about three inches and bound in that position with friction tape. In some of the tests on multiple-conductor buried cables a large iron clamp was used to force the conductors together. Several investigations were made also on copper-to-copper and copper-to-ground faults of the point-contact class.

Remains of single-conductor non-magnetic-sheath cables and ducts after test

(Left) total current—0 to 5,000 amperes for 11.5 min.; (right) total current — 0 to 3,600 amperes for 21.5 min.

Conclusions

Results of these tests, together with other information obtained from operating data and previous publications, are summarized in the following general conclusions:

1. Point-contact and conductor-to-sheath faults.

Faults of this type occurring in single-conductor lead-covered cables in 120/208-volt networks usually were cleared within a period of several seconds irrespective of conductor size where the minimum current available was approximately 3,000 amperes.

2. Copper-to-copper faults.

These faults, made as described by taping the bared conductors together for a length of about three inches, will clear at the fault location within one minute's time (usually less) provided certain minimum values of short-circuit current (see accompanying table) are maintained during the entire short-circuit period.

MINIMUM SHORT-CIRCUIT CURRENT FOR CLEARING COPPER-TO-COPPER FAULTS IN SINGLE-CONDUCTOR CABLES

Conductor size	Short-circuit current in amperes: Per conductor	Total
No. 4/0	3,000	6,000
350,000 cir. mils	4,000	8,000
500,000 cir. mils	5,000	10,000

3. Faults in buried cables.

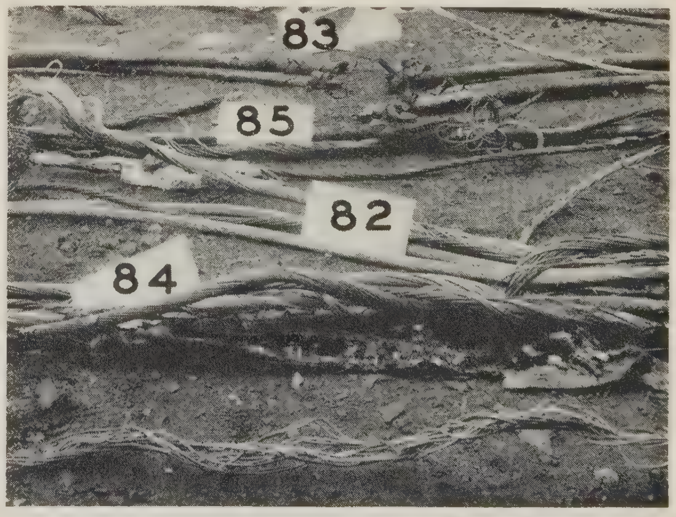
Buried single-conductor non-magnetic-sheath cables when dropped into the trench at random possess approximately the same general burn-off characteristics as do single-conductor cables installed in four-inch non-metallic ducts. These characteristics are improved somewhat by separating the cables.

4. Faults in buried multiple-conductor cables.

Burn-off characteristics of this type of cable with non-magnetic sheath makes it undesirable for low-voltage a-c. network distribution. The better burn-off characteristics of buried single-conductor cables are attributed largely to a wider separation of the conductors, and coverings impregnated with a flameproof compound.

5. Oiled paper *vs.* rubber insulation for buried cables.

In the matter of burn-off characteristics vulcanized sulfinated oiled-paper insulation appears to offer no improvement over ordinary rubber insula-



500,000-cir. mil paper-insulated lead-covered cables removed from ducts after test

Note cables of test No. 83 in which a total current of 10,400 amperes cleared a 3-in. contact fault in 1.25 min. Initial current for the remaining cables was from 7,300 to 9,000 amperes

tions. Analyses show no appreciable difference in the explosibility and inflammability of gases produced with either type of insulation on lead-covered cables.

6. Time required for fusing.

Assuming current values to be constant calculated values of fusing time are sufficiently accurate for all practical purposes provided total arcing time does not exceed approximately eight minutes.

7. Gases liberated during fault period.

With either oiled-paper or rubber insulation, explosions may occur due to gases liberated by arcing faults in underground cables if these faults persist for more than five minutes.

Analyses of these gases indicate that approximately 50 per cent of the gaseous mixture is combustible; and laboratory tests show that the gases from both types of insulation contain in general the same constituents and are evolved in the same relative quantities. Gases emanating from the burning of fiber duct now used in underground systems do not appear to affect the combustibility of the gaseous mixture from an arcing fault.

As stated, the foregoing conclusions are based upon operating data and results of the tests outlined in this article which were made upon cables buried in both relatively dry and in relatively wet soil, and others installed in relatively dry ducts. In addition to the conclusions already outlined the tests indicate certain other burn-off characteristics desirable in cables for use in a-c. low-voltage underground networks. Development of new insulating materials to provide these cables with such characteristics will require further research and experimentation.

Transient Voltages in Auto-Transformers

Effects of transient voltage phenomena upon auto-transformer design are discussed briefly. Results given are based upon tests.

By
K. K. PALUEFF
Member A. I. E. E.

General Elec. Co.,
Pittsfield, Mass.

GENERAL PRINCIPLES controlling the high-frequency voltage phenomena within auto-transformer windings are the same as those governing such phenomena in ordinary transformer windings. Since these principles have been discussed previously (A. I. E. E. TRANS., Vol. 38, p. 477; Vol. 48, p. 681; Vol. 48, p. 998; and Vol. 49, p. 1179) this should be looked upon as a continuation of that discussion and as written on the assumption that the reader is thoroughly familiar with the papers mentioned in those references.

To clarify the terms used, it should be noted that here:

1. The transmission line that brings a given surge to an auto-transformer is called the "primary line," while the other line of the auto-transformer is called the "secondary line."

2. The transmission line connected to the highest point of the auto-transformer winding is termed the "high-voltage line," while the line connected to the intermediate point is termed the "low-voltage line."

3. Part of the winding between the high-voltage and low-voltage lines is called the series winding, and the remaining part between the low-voltage line and ground is called the common winding.

From "Effect of Transient Voltages on Power Transformers—III—Non-Resonating Auto-Transformers," (**No. 31-41**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

Ordinary Auto-Transformer

In an auto-transformer two points of the winding are connected to transmission lines and it is this feature that makes the oscillation of an auto-transformer winding essentially different from that of an ordinary transformer winding. Because of the two independent transmission lines connected to the same winding, four different conditions of surge excitation are possible:

1. Surge arrives from high-voltage line.

2. Surge arrives from low-voltage line.

3. Two surges of the same polarity arrive simultaneously, one from each line.

4. Two surges of opposite polarity arrive simultaneously, one from each line.

The first two cases are the most common; the last two are rare because they may occur in two cases only, (1) when the lines are parallel and (2) when the lightning storm takes place directly over the auto-transformer.

Surge from High-Voltage Line

It is obvious that when a surge arrives from the high-voltage line the voltage distribution throughout the winding will be influenced by the potential rise of the low-voltage line arising from the surge transmitted through the auto-transformer windings. The magnitude and wave shape of the voltage rise of the secondary line depend upon (1) the shape of the incident wave, (2) the surge impedances of primary and secondary lines, (3) the effective inductance and turn ratio of the auto-transformer, and (4) the length of the secondary line. In most practical cases the rise of potential of the secondary line is slow as compared with the internal oscillation of the auto-transformer windings. Because of the finite length of the incident wave, and the rela-

tion of the surge impedances and inductances found in practise, the ultimate potential of the secondary line is found to be a small fraction of the crest value of the incident wave of the primary line.

For these reasons the phenomena of oscillation of the series winding can be divided conveniently into two parts, (1) the rapid internal oscillations and (2) the relatively slow potential rise of the secondary line terminal. This permits the assumption that in most cases found in practise the secondary line acts as a solid ground for the internal oscillations produced in the windings by lightning disturbances originating on the primary line. Thus it may be said that the part of the winding between the terminals of the two lines oscillates as if the secondary terminal were solidly grounded. The part of the winding between the secondary terminal and neutral oscillates practically as a short-circuited secondary winding of a transformer, while the secondary terminal potential rises above ground at a substantially lower rate.

Practically full voltage of the incident wave appears across the series winding. In case the series winding has substantially fewer turns than the common winding, appreciable internal overvoltage may be created in the common winding by the step-up action due to mutual inductance between series and common windings. This fact is responsible also for the appearance of much higher voltages between turns of the series winding than would be found in transformer windings of the same voltage rating, or in the same auto-transformer with the low-voltage line disconnected. It follows that both of the effects mentioned may be particularly prominent in auto-transformers interconnecting transmission lines of closely similar operating voltages. The foregoing phenomena are characteristic of all auto-transformers.

Both amplitude and shape of secondary-line wave for any shape of incident wave on the primary line may be computed theoretically. Experimental study with different shapes of incident wave has confirmed the calculated results very satisfactorily.

With engineering accuracy it may be stated that, to the greatest part of the lightning wave as transmitted from the primary to the secondary line, an auto-transformer acts as an ordinary inductance connected between the two lines. The value of this inductance may be found by dividing the ohmic short-circuit reactance of the auto-transformer obtained at operating frequency, by 6.28 times the operating frequency.

Surge from Low-Voltage Line

In this case an incident wave strikes the series and common windings simultaneously at their point of contact. Since the other end of the common winding is grounded permanently, and that of the series winding is connected to a transmission line, the oscillations of both windings are similar. This similarity, however, disappears in case of a substantial difference in the number of turns in the series and common windings. This happens because of the prominence in such a case of the step-up action referred to before.

Simultaneous Surges

Cases of simultaneous surges are very rare; therefore no space will be devoted to their discussion here.

In case the high-voltage line is disconnected, an incident wave from the low-voltage line will cause the common winding to oscillate as a solidly grounded winding, and the series winding to oscillate as a winding completely isolated from ground, as was described in previous Institute papers. In case the low-voltage line is disconnected and the incident wave arrives from the

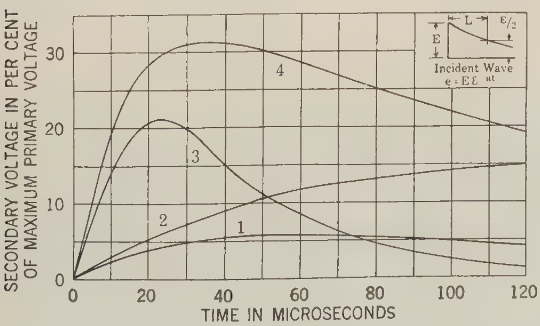


Fig. 1. Curves showing voltage at low-voltage terminal of a transformer with incident wave applied to high-voltage terminal

1 and 3.—Length L of incident wave 20 microsec.
2 and 4.—Length L of incident wave 100 microsec.
1 and 2.—High effective auto-transformer inductance
3 and 4.—Low effective auto-transformer inductance

Long secondary line; surge impedance of both lines, 300 ohms; auto-transformer ratio 2:1. High effective inductance covers range from 20,000 kva., 220 kv. Y to 1,000 kva., 66 kv. Y; low effective inductance from 80,000 kva., 220 kv. Y to 10,000 kva. 66 kv. Y

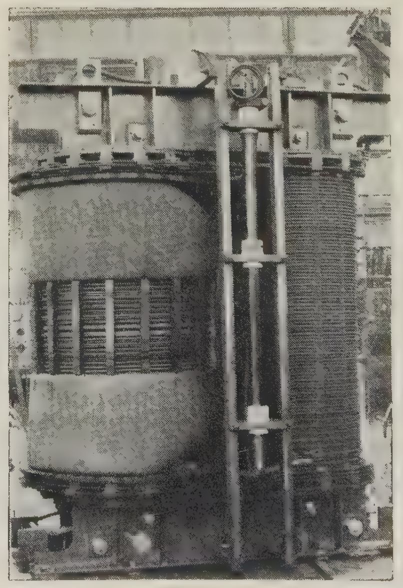


Fig. 2. A commercial 20,000-kva. 215/107/11-kv. non-resonating auto-transformer

high-voltage line, the entire winding oscillates as an ordinary transformer winding with solidly grounded neutral.

Non-Resonating Auto-Transformer

To reduce the danger associated with internal voltage oscillations, which cause abnormally high concentration of local stresses, a non-resonating auto-transformer has been developed and applied to practise. Tests have shown that it gives substantially uniform transient-voltage distribution. Underlying principles governing the construction are very similar to those which apply for non-resonating transformers.

The presence of two transmission lines connected to two different points of the winding causes some modification in the proportioning and distribution of shields as compared with that in a non-resonating transformer. In general appearance and construction, however, the non-resonating auto-transformer is very similar to the ordinary non-resonating transformer.

It is the author's opinion that the non-resonating auto-transformer is particularly well adapted to the concentric construction of windings typical of core-type transformers. Its windings are uniform mechanically as well as electrically, and free of the points of discontinuity and breaks which are characteristic features of interleaved windings. These breaks are points of extremely high voltage concentration. In spite of this fact, however, their dielectric strength often is made proportional to the test voltage produced across them during standard A. I. E. E. induced-voltage tests. Such grading of major insulation, of course, is not justified because in an ordinary auto-transformer, as contrasted to the non-resonating auto-transformer, the distribution of transient-voltage stresses does not correspond to the distribution of stresses created by standard low-frequency tests.

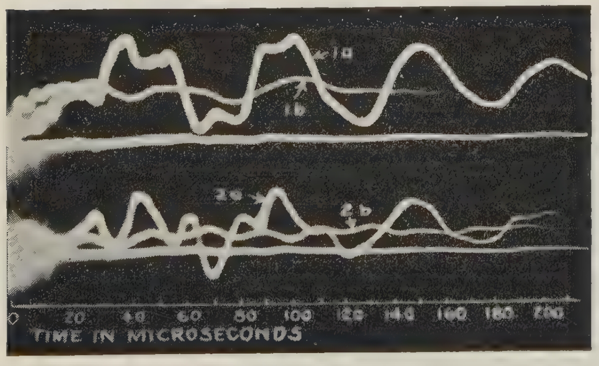


Fig. 3. Oscillograms showing internal voltages in a commercial non-resonating auto-transformer

1*a*.—32 per cent from neutral without shields

1*b*.—32 per cent from neutral with series and common windings shielded

2*a*.—12 per cent from neutral without shields

2*b*.—12 per cent from neutral with series and common windings shielded

Long rectangular wave applied to high-voltage terminal with low voltage lines disconnected. Tests made in air, thereby creating some electrostatic unbalance

Conclusions

Ordinary Auto-Transformer

1. With only one transmission line connected to an auto-transformer, a traveling wave produces internal oscillations similar to those produced in an ordinary transformer.

2. With both transmission lines connected to their respective terminals, a traveling wave impressed from one line creates two kinds of voltage transients in the windings; the first is relatively slow and responsible for the rise of potential on the secondary line; the second is relatively fast and consists of internal free oscillations in the windings.

3. For the internal free oscillation, a secondary line of sufficient length acts in most cases as a solid ground.

4. Internal stresses, particularly those between turns, are higher in an auto-transformer than in an ordinary transformer of the same voltage rating. This condition becomes aggravated as the auto-transformer voltage ratio approaches unity.

Non-Resonating Auto-Transformer

1. Auto-transformers can be built which are non-resonating for usual conditions of operation.

2. The windings of non-resonating auto-transformers are uniform and free of breaks.

3. Non-resonating auto-transformers are similar to ordinary non-resonating transformers in general appearance and construction.

An Improved Welding Generator

A neutralizing d-c. transformer removes troublesome transients from current output of welding generator.

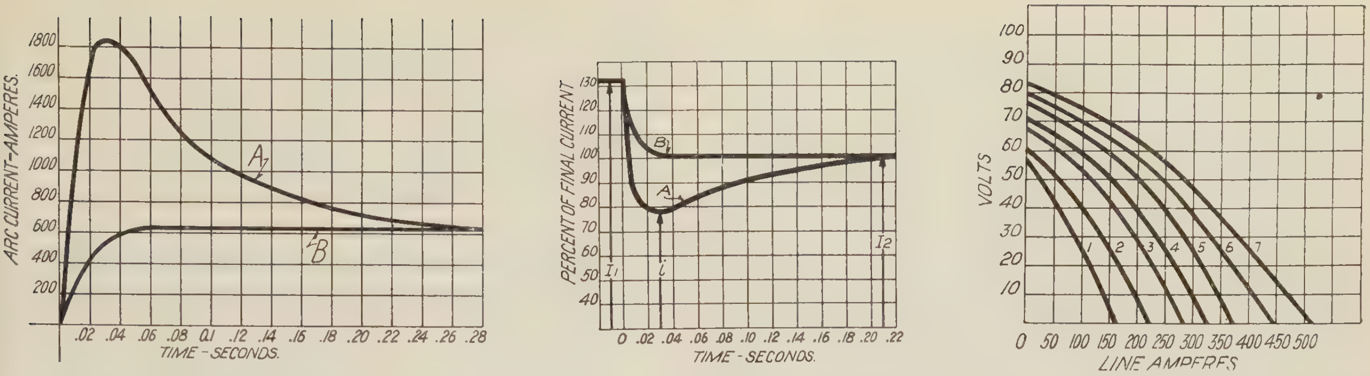
By
J. H. BLANKENBUEHLER

Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

TROUBLES most commonly experienced with welding generators of inferior characteristic are (1) fusion of the electrode solidly to the parent metal upon contact and (2) frequent extinction of the arc by slight disturbances.

When contact is made between a new electrode and a cold plate neither should be melted until an arc is drawn; however, if the contact resistance and instantaneous short-circuit current are sufficiently high immediate fusion at the contact point will occur.

From "An Improved Arc-Welding Generator," (**No. 31-13**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.



Welding current at short circuit on a typical welding generator. Curve A, ordinary design; curve B, with transforming reactor in field circuits

Welding current for sudden increase of voltage from 15 to 25 across the arc. Curve A, ordiuary design; curve B with transforming reactor in field circuits

Family of curves for a 7.5-kw., 25-volt-1,750-r. p. m. separately-excited differen, tially-compounded arc-welding generator

Fig. 1. Output current curves for typical arc-welding generators

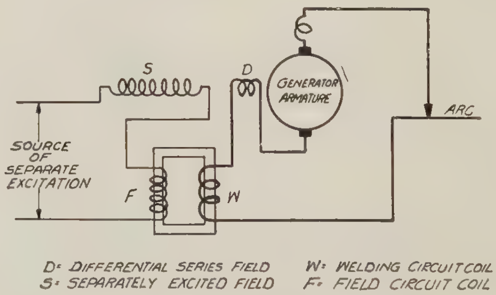
With the resistance thereby reduced, the molten spot solidifies and the electrode is "frozen." To obviate this difficulty it is necessary for a generator to have not only a low ratio of short-circuit current to welding current, but also to have no momentary current rise above the stable short-circuit value.

The operator's other annoyance, arc instability, is explained by the fact that in any particular arc there probably is a minimum value of current below which the arc will become extinguished. The actual value of such minimum current is dependent upon arc length, size and material of electrode and welded object, magnetic conditions about the arc, presence of flux or stabilizing gases, velocity of air blowing on the arc, and many other factors. Assuming this minimum current to exist, it can be said that any disturbance at the arc, which reacts on the generator so as to allow the current to drop below the minimum stable arc value, will extinguish the arc. To obviate this difficulty, then, it is apparent that the generator must accommodate changes arising from instantaneous variations in load (arc) resistance without permitting the delivered current to drop even momentarily below the minimum stable value.

Natural reactance within the welding circuit tends to overcome both difficulties by smoothing the welding current, and the addition of sufficient reactance to the circuit of course would approximate the desired results. An adequate reactance, however, would be large and prohibitive in power loss.

Practical experience, extensive tests, and numerous

Fig. 2. Method of connecting neutralizing transformer



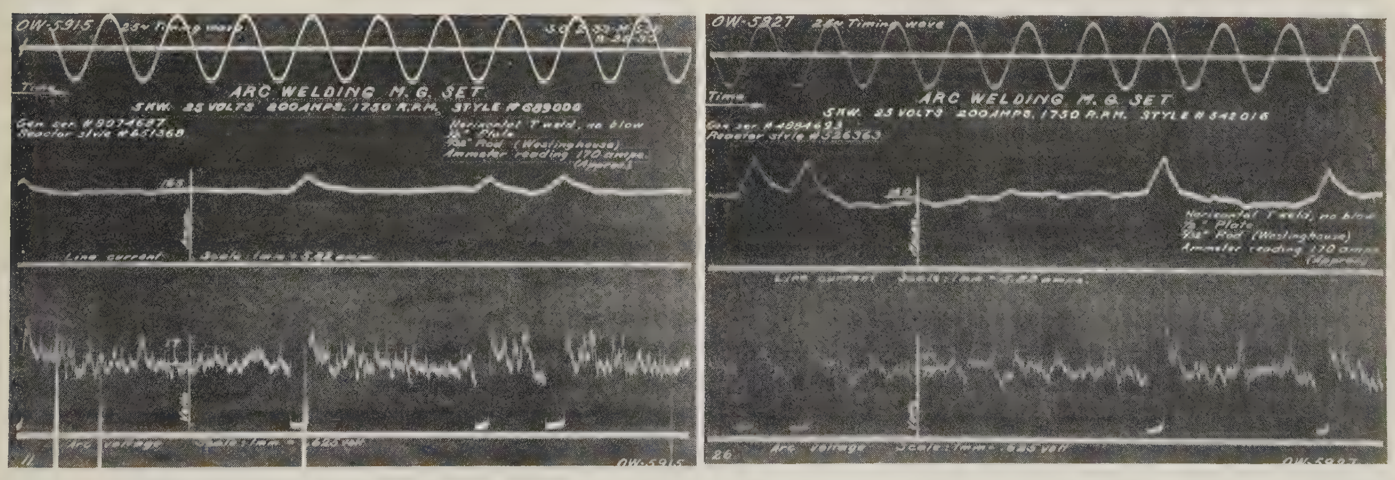


Fig. 3. Oscillographic record of a manual horizontal T-weld on 1/2-in. plate with 5/32-in. rod and 170 amperes and no magnetic blow (left) with neutralizing transformer and (right) with ordinary reactor

oscillographic records show conclusively that a generator having the short-circuit characteristics shown by curve B in Fig. 1 (left) and the arc-lengthening characteristics of curve B in Fig. 1 (center) produces a flexible and easily managed arc. The approximate constant-current volt-ampere characteristic best suited to a single-operator welding generator can be obtained most efficiently with a separately-excited differentially-compounded machine. Because of the current in the series field the voltage of this type of generator naturally follows the arc voltage for any given shunt-field current as a result of the inverse action of the series field. Typical curves are given in Fig. 1 (right). As previously implied, however, in addition to the ultimate steady-state condition it is imperative that the response be practically instantaneous in order to obviate the undesirable transients. In the ordinary design such rapidity of response is impossible because of the effects of magnetomotive force interlinkage among generator coils and the resulting transformer action. This delaying effect is demonstrated by the surge of curves A of Fig. 1 (left and center). Elimination of the surges requires that by the time the current builds up to its final value, the flux shall have changed to its final value.

Magnetomotive forces produced by currents induced in every conductor linking the flux retard the requisite change. Extensive tests have shown, however, that from a practical standpoint only the hindering effects developed within the field coils themselves are of sufficient magnitude to be important. Thus the problem reduces to that of preventing the development of undesired induced counter electromotive force within the field coils, or of neutralizing its effect by introducing into the field circuit an opposing voltage approximately equal at every moment to the instantaneous induced voltage.

The logical method of producing the required neutralizing voltage is to use a transformer with its primary in the welding circuit and its secondary in the field circuit as shown in Fig. 2. With the series field and the transformer primary in series, and hence carrying identical currents, any change in current will affect both at the same instant and the transformer secondary voltage will neutralize any voltage induced into the field coils as a result of the change.

Another feature of the system lies in the fact that by the proper proportioning of transformer primary and secondary the field current can be changed to induce a magnetomotive force which will promote the desired flux change; this force can be used to offset any retarding forces arising outside of the field coils: The device is equally effective in neutralizing the retarding effect of the field coils on any type of welding generator whether separately- or self-excited.

In addition to the ease of striking and maintaining a satisfactory arc with the described device, tests show a greatly decreased porosity of weld and improved efficiency in metal deposit.

A Telegraph Testing Machine

Telegraph line efficiencies and signal distortion measurements are only two of the many uses for this unique device. By means of an unusual electrochemical recorder, time intervals of one ten-thousandth of a second in the opening and closing of electrical circuits are graphically recorded.

By
F. B. BRAMHALL
Associate A. I. E. E.

Western Union Telegraph Co. New York

ANY MEASUREMENT of the quality of telegraph transmission is of necessity a measurement of the extent to which the received signaling pulses are distorted from the form in which they were originally transmitted. For the purpose of this article, signal distortion will be defined as the deviation in length and time relationship of the received signal pulses, from the absolute length and time relation of their transmission. This definition confines the measurement of distortion to the measurement of the time relationships which obtain between the signaling pulses as repeated by a relay or other repeating instrument. The unique arrangement of the electrochemical recorder of the transmission testing machine adapts it especially to the measurement of these time relationships.

A conception of the principle of the machine can be formed most readily if it first be considered as arranged for local testing of circuits both ends of which are available at the test point. Referring to Fig. 1, the commutator transmits signals to the circuit or apparatus under test. These signals operate a relay at the receiving end of the test circuit; the relay contacts control the potential applied between a metallic marking needle carried on an arm on the revolving shaft of the machine, and a metallic platen over which a saturated electrochemical recording tape passes. The arm which carries the marking needle revolves on the same shaft with the transmitting brushes, the revolving metallic marking needle making a light contact with the surface of the saturated paper tape. The chemical solution with which the tape is moistened and the material of the

From "Telegraph Transmission Testing Machine," (**No. 31-17**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

marking needle are such that when the proper polarity of potential is applied to the needle a deep blue mark results from the electrochemical action. If in response to a transmitted signal pulse, the receiving relay energizes the marking needle during the time of its transit across the recording paper, a mark is made continuously until the needle is again deenergized at the termination of that pulse. Thus if transmission over the circuit under test be perfect, the revolving needle draws a line on the paper tape which is a true projection of the arc of

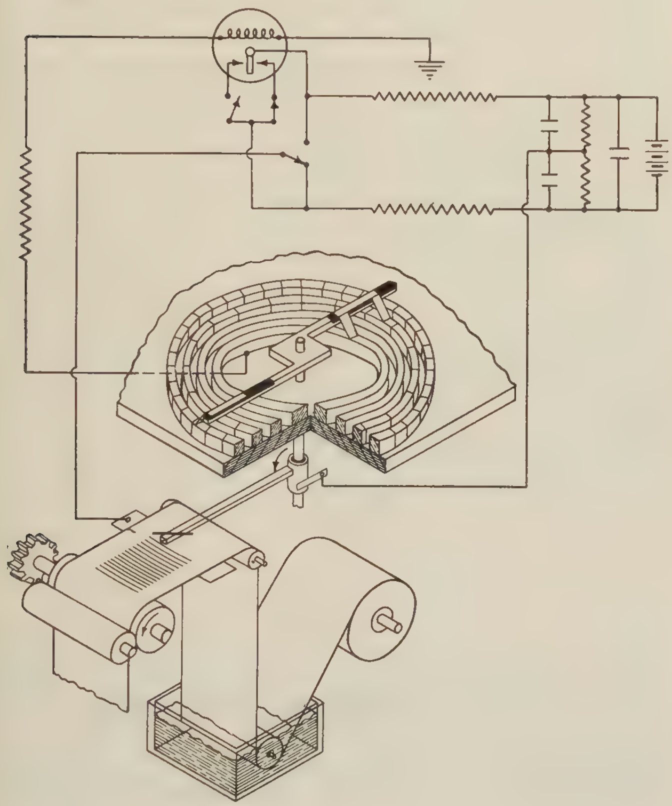


Fig. 1. Details of chemical recording mechanism. Note that recorder needle and commutator arm are mounted on the same shaft

the transmitting segment of the commutator. The recording tape moves at a slow rate; just sufficient to separate slightly the succeeding recorded marks.

Transmission and reception of signals by a common rotating member is obviously not essential in this method of measuring but may be performed by separate rotating members so long as proper synchronism of rotation is maintained. It is through the use of carefully synchronized transmission and reception that point-to-point testing is done.

In transmission measurement work of any kind it is common to use selected combinations of test signal pulses, either such combinations as represent certain letters in the signaling code or perhaps those which experience has shown are most susceptible to "fortuitous" and "characteristic" distortions. Fortuitous distortion is the shortening or lengthening of signal pulses which results from extraneous disturbing currents in the signaling circuit or from irregular and improper functioning of receiving or repeating instruments. Characteristic distortion is the shortening or lengthening of signal pulses, which is governed by the sequence of the pulses themselves and by the electrical and magnetic characteristics of the signaling circuits and apparatus.

For convenience, the transmission testing machine is equipped with a multi-point rotary switch which quickly sets up on the transmitting commutator any one of a number of predetermined test signal combinations.

Uses of the transmission testing machine in the analysis of signal distortions are most conveniently explained with the aid of sample records. Reproductions of typical records are shown in Figs. 2 to 5. In the more common classes of measuring work two test records are obtained, one showing the repetition from either contact of the receiving instrument. Through comparison of the two, bias of signals is either eliminated or quantitatively determined. Only one record is reproduced here in each case.

A record of substantially perfect transmission of signals repeated by a good polar relay operating in a

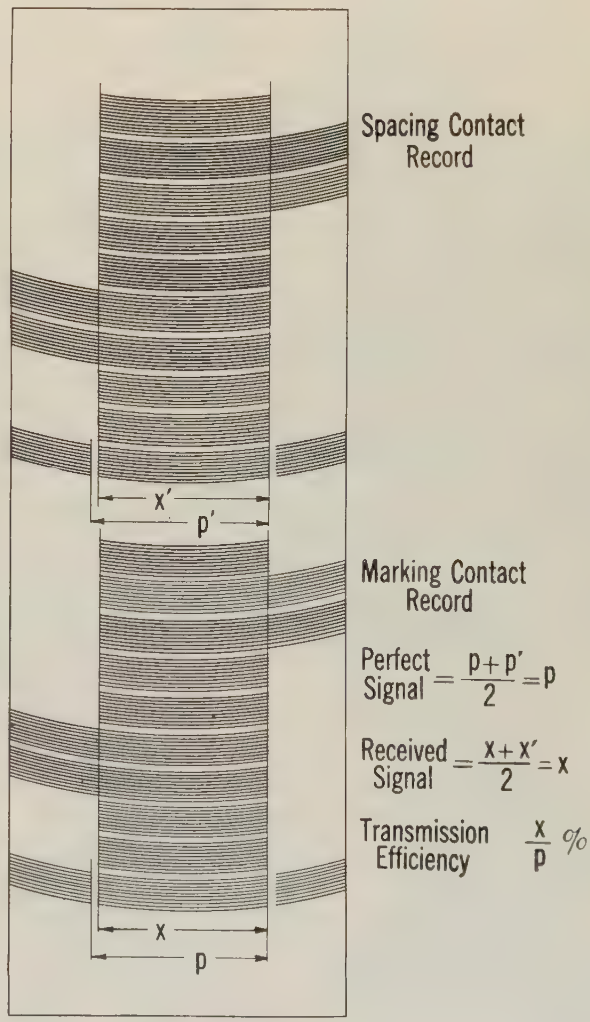


Fig. 2. Typical record of good polar relay operation

local circuit is shown in Fig. 2. At the bottom of this record is shown a short section made with the recording circuit so arranged that the marks are continuous except for the time that the relay tongue is not in contact with either of its stops. In this portion of the record the length of the breaks in the traces made by the recording needle is proportional to the "transit time" of the relay armature.

Typical performance of a poorer repeating relay is shown in Fig. 3. This record illustrates both a "transit time" loss and the loss due to the rebound or "chatter" of the tongue contact against its stop. A common form of characteristic distortion (that caused by a sluggish circuit or instrument) is shown in Fig. 4 together with a typical example of fortuitous distortion caused by a line disturbance. The periodic nature of this disturbance is evident in the regular beats produced in the received signals.

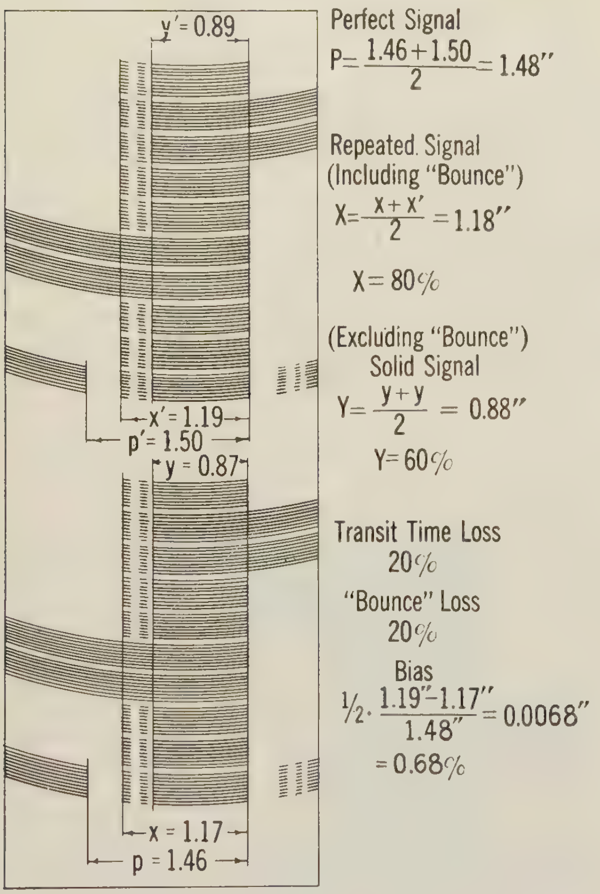


Fig. 3. Typical record of improper polar relay operation

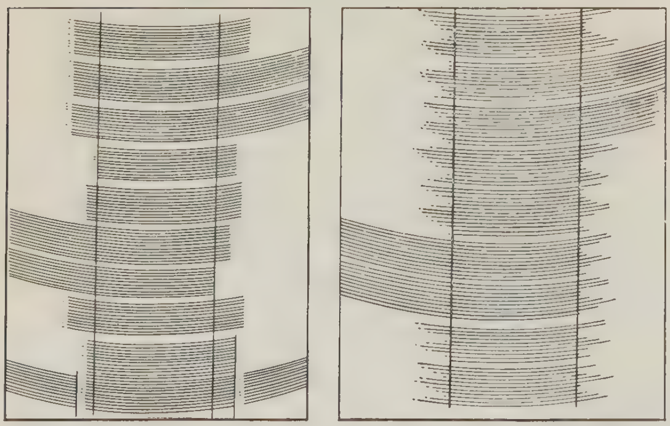


Fig. 4. Records of typical signal distortion; (left) "characteristic;" (right) "fortuitous"

Records of over-all transmission in straightaway and field testing work are made by arranging the recording circuits so that the only traces made by the recording needle are those representing the open-circuit time of the receiving-relay contacts. These "negative" records convey the same information as do those of the other type and in this class of testing are generally preferred. They are desirable particularly where the test pulse combinations are of the nature of "traffic" signals.

The transmission testing machine finds a wide field of usefulness both in the measurement of over-all transmission efficiencies and in the analysis of transmission losses. It may be used as a monitoring recorder to check the distortion of "traffic" signals at either repeater or terminal points. Obviously it is not limited to the polar, two-element, class of signal work chosen for the explanation. It is as readily used for work on ocean-cable circuits employing a three-element code, and on neutral Morse or carrier circuits.

Average-Voltage Method for Transformer-Loss Measurement

By
ARAM BOYAJIAN
Fellow, A. I. E. E.

General Electric Co.
Pittsfield, Mass.

IN THE LATEST issue of the A. I. E. E. STANDARDS (May, 1930), Sec. 13, Par. 13-306, the following appears:

"The no-load loss of transformers shall be determined preferably with a sine wave of applied voltage; if this is not practicable, the results obtained with a distorted wave of applied voltage shall be corrected to a sine-wave basis." And, foot-note: "For correcting to the sine-wave basis, a method based on the measurement of average voltage is recommended."

The reason and basis for the adoption of this rule and recommendation by the A. I. E. E. is explained in the following discussion.

Unlike its load loss, the no-load loss of a transformer is very sensitive to wave shape and different test-voltage wave shapes cause radically different values to be obtained in its measurement. Therefore the no-load loss

guarantee on a transformer means little unless the test result is reduced to a sine-wave basis.

Most of the no-load loss in a transformer is hysteresis loss. This is not a function of the *effective value* of the flux density or voltage, but is a function of the peak value of the flux density, which in turn is proportional to the arithmetic *average value* of the voltage. Peaked-voltage waves produce flat-topped flux waves and low-hysteresis loss, whereas flat-topped voltage waves produce peaked-flux waves and high-hysteresis loss. In commercial tests, the voltages usually become peaked and may lead to measurements which often are 10 and occasionally as much as 50 per cent too low. A no-load sine-wave voltage of a generator is no assurance of reliable results, because the distorted exciting current of the transformer under test usually materially distorts the terminal-voltage wave of the generator.

The amount of distortion caused by the transformer exciting current is roughly a function of the ratio of the transformer kva. rating to the generator kva. rating. Other factors that enter in are the percentage synchronous reactance of the generator, percentage field excitation of the generator, and the flux density of the transformer. To avoid objectionable distortion under such a load were no means of reduction to sine-wave basis used, the generator kva. rating would have to be much larger than the transformer rating. (With a dependable method of reduction to sine-wave basis, very much smaller ratios of generator capacity to transformer capacity may be used in such tests.)

Heretofore approximate correction for wave distortion has been made usually by means of a small auxiliary "standard" core calibrated on sine-wave voltage. This standard core is excited from the same source simultaneously with the transformer under test, and with the aid of its calibration curve a correction is applied either to the test voltage or to the wattmeter reading.

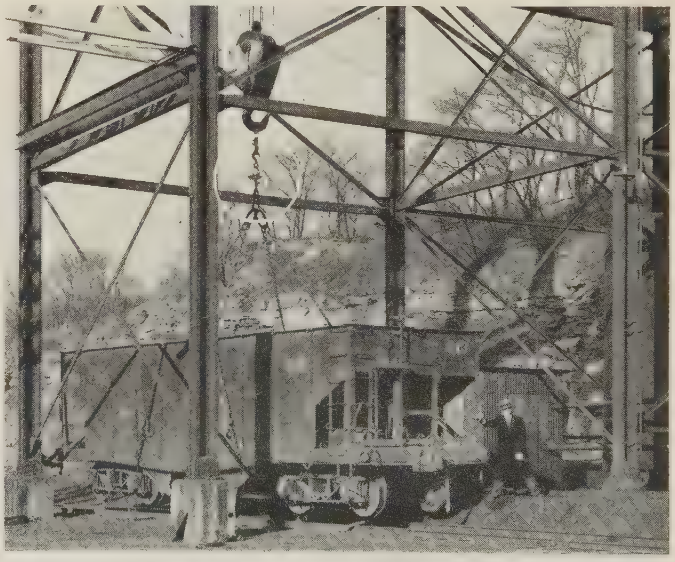
This method of correction for wave distortion, though infinitely better than the use of no correction at all, is not very satisfactory, because no standard core could be representative of sheet steel of all grades and types used, nor of the wide range of densities at which different transformers are designed to operate. Under unfavorable conditions the use of a "standard" core has been found to lead to errors of even more than 10 per cent.

Since hysteresis loss is not a fixed known function of density for all kinds of sheet steel at all densities, obviously the only way to assure correctness of the tested value is to maintain the correct maximum flux density. Mathematically it has been proved that the maximum flux density is proportional to the arithmetic *average value* of the voltage, and therefore that with an instrument reading the average value of an alternating voltage instead of its r. m. s. value, correct density in the transformer under test can be preserved irrespective of the voltage wave shape. If an average-reading voltmeter is calibrated on a sine wave or, more conveniently, on a d-c. source, and then is used to determine the test voltage, correct density and hysteresis loss in the transformer are assured. Results are practically independent of the type of core steel used in the transformer, and correction need be made only for the eddy-current component of the no-load loss. This is a relatively small correction and can be made very accurately.

The average-voltage method was not commercially practicable until a few years ago when G. Camilli showed how an average-reading voltmeter could be constructed using a vacuum-tube rectifier and d-c. voltmeter. Since the instrument was to be used for maintaining correct flux in a transformer it was named appropriately a "flux voltmeter." "A Flux Voltmeter for Magnetic Tests," A. I. E. E. JL., October 1926, p. 989, disc. 1014.) Since then the instrument has been improved further by the use of a small copper-oxide rectifier instead of the vacuum-tube rectifier, and is available commercially.

In addition to the much greater accuracy obtained by the average-voltage method, there is the advantage that a given no-load-loss measurement can be checked very easily even in the field by any one using a flux voltmeter. The calibration of the instrument also is simple; it can be done on direct current.

Suspension Insulator Lifts 20-Ton Load



Westinghouse E. & M. Co. Photo

NEW developments such as railroad electrification with heavy cables tightly strung are demanding mechanical strength in insulators which requires all the designer's skill to furnish. Just as a demonstration of its strength this new 12-in. heavy-duty insulator, which is thought to be the strongest of normal type ever built, may be seen lifting a 20-ton steel car off the rails, trucks and all. The greater strength has been obtained not by using more material but by a more accurate knowledge of materials in general, and a more precise calculation of the distribution and transfer of stresses.

Insulation Research Advances Are Recorded

The quest for a better understanding of important problems underlying the improvement of electrical insulation is proceeding definitely through channels of research into related fundamentals, as outlined in the January issue of ELECTRICAL ENGINEERING (pp. 24-29). During the first half of 1931 some seven papers have been presented before Institute conventions and District meetings covering certain specific efforts in insulation research. Two of these papers concerned themselves with cable oils, two with impregnated paper, and three devoted primary attention to mathematical attacks upon insulation problems. In whole or in part in several instances these same papers were discussed at the Washington, D. C. meeting (Nov. 7-8, 1930) of the National Research Council's electrical insulation committee, which conference was comprehensively reviewed in the January 1931 issue of ELECTRICAL ENGINEERING. All of the papers in question have been reviewed briefly in current news reports appearing in ELECTRICAL ENGINEERING, but because of the importance of the subject and for the benefit of those it may serve, the following group of brief abstracts is published.

The Conductivity of Insulating Oils

By
J. B. WHITEHEAD
Fellow A. I. E. E.
Johns Hopkins University, Baltimore

CONTINUOUS-CURRENT characteristics of several insulating oils are studied for time intervals beginning 0.001 sec. after the application of voltage or short circuit. Essential equipment is the amplifier oscillograph in connection with a quick-acting switch. It is found that in one group of oils there is an initial conductivity which is constant over the period of the first second following the application of the voltage. Thereafter there is a slow decrease of conductivity to a final value much lower than the initial value. It is shown that this initial constant conductivity is sufficient to account for all of the dielectric loss under alternating stress.

In another group of more carefully refined and deaerated oils there is superposed upon the brief initial constant conductivity a still shorter initial evidence of dielectric absorption. During the first few thousandths of a second the charging current decreases sharply; is followed thereafter by a constant conductivity up to about one second, and thereafter decreases further to a much lower value after a long time. The initial absorption period has a corresponding discharge curve on short circuit. The measured value of the alternating loss in this case is completely accounted for by the sum of the loss due to the initial period of absorption in combination with the succeeding short-time-constant conductivity.

Other results are presented on the variations of the initial and final conductivities with the voltage and with temperature. The final currents show saturation characteristics, but the initial high conductivities do not.

Among the conclusions reached are the following:

1. Certain high-grade insulating oils have electrical characteristics similar in type and comparable in magnitude to those of the carefully refined poorly conducting liquids used in physical research.

Conductivities of the order 10^{-15} mhos per cu. cm. are common.

2. In the purest state they show a definite though brief dielectric absorption.

There are in fact three definite stages of conductivity: (A) an initial brief, rapidly descending value with corresponding curves for charge and discharge current, thus indicating the presence of dielectric absorption.

From "The Conductivity of Insulating Oils," (**No. 31-40**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

The duration of this phase is of the order of 0.004 sec. (B) An approximately constant value of conductivity within the interval 0.004 to 1 sec. (C) A very slowly decaying conductivity reaching a constant value only after 30 min. or more.

3. Initial dielectric absorption increases with decrease of temperature and thus is associated with the viscosity.

It is difficult to measure at 60 deg. or in an oil slightly deteriorated. In these cases the absorption, if present, is obscured by the greater value of conductivity of stage (B).

4. Dielectric loss under 60 cycles alternating stress is determined definitely by the continuous-current characteristics within the interval 0 to 0.1 sec.

Loss at the higher temperatures and for oils having high initial conductivity is accounted for completely by the conductivity of stage (B). For the purest and best oils below 60 deg. the alternating loss is accounted for completely by the conductivity of stage (B) plus the loss computed from the curve of dielectric absorption pertaining to stage (A). At 30 deg. this second component may represent 35 per cent of the total loss.

5. Initial absorption, conductivity, and subsequent decay are not completely accounted for by residual impurities, as frequently stated.

It is highly probable that they are due in part to the variety of molecular complexes and groupings occurring in such hydrocarbons, resulting in a heavy slow-moving type of ion which is subject to wide variation in properties with the value of the electric intensity and with other external influence. Thus these ions which give rise to the initial stages of conductivity probably are quite different from those involved in the final conductivity, and which have been used by Jaffe and others for drawing analogies between the conductivity of a liquid and of a gas. In fact there is no immediate evidence that this latter type of ion is involved in the alternating loss at commercial frequencies.

Some Electrical Characteristics of Cable Oils

By
HUBERT H. RACE
Assoc. A. I. E. E.
General Electric Co.
Schenectady, New York

ROUTINE measurements of d-c. resistivity are dealt with in the first part of this paper, along with a description of a quartz-insulated testing cell and a portable testing set for use with it. Absolute resistivity between 1×10^9 and 1×10^{13} ohms can be measured at any temperature up to 150 deg. cent. Among the conclusions are:

1. Data indicate that for comparative resistivity measurements it is necessary that the samples be thoroughly dry and that they be protected from light and heat before the measurements are made.

2. For comparing the electrical characteristics of commercial insulating oils, d-c. conductivity measurements are preferable to low-frequency bridge measurements since they give the same information and are easier to make.

Variation of apparent d-c. conductivity of a heavy cable oil with potential gradient and with temperature are shown in the second part of this paper. Data show that the conductivity is constant only for very low gradients. An approximate mathematical relation is developed to represent the conductivity both as a function of potential gradient and of temperature. Measurement of the apparent d-c. conductivity of a heavy cable oil as a function of temperature and of potential gradient gave the following results:

1. Potential gradient must be kept below 20 volts per mil to assume constant conductivity for temperatures as high as 100 deg. cent.

2. The lower the temperature the higher the critical gradient below which conductivity is independent of gradient.

3. The lower the temperature the more rapid the increase in conductivity for gradients higher than this critical gradient.

4. Variation of apparent d-c. conductivity with both temperature and potential gradient may be represented approximately by the equation

$$\gamma = \gamma_0 \, \epsilon^{\alpha T} \, \epsilon^{\beta g}$$

in which, for the oil tested,

$\gamma_0 = 3.48 \times 10^{-23}$ mho. per cm.^{3}
$\alpha = 0.0633$ per deg. abs.
$\beta = 12.64\,(100/T)^6$ per volt per mil.
T = temperature in deg. abs.
g = maximum potential gradient in volts per mil.

5. In conducting those experiments, convection currents were observed in the oil, indicating that the increase in conductivity at high gradients may result from increased mobility of charged aggregates.

Observed variations of dielectric coefficient and dielectric loss with temperature and frequency for a viscous cable oil are summarized in the third part of this paper. Analysis shows the total dielectric loss to be the sum of two components, one due to conduction and the other qualitatively explained by Debye's theory of polar molecules. On the basis of measurements made on carefully refined water-free mineral insulating oil through a temperature range from − 50 to 150 deg. cent. and a frequency range from 300 to 2×10^6 cycles per sec., it is apparent that:

1. At frequencies lower than 300 cycles per sec. and at temperatures greater than 25 deg. cent., the total dielectric loss may be accounted for by conduction only. Thus at 60 cycles per sec. it is only at very high viscosities that there is any appreciable loss except that resulting from conduction. For this reason d-c. conductivity measurements are sufficient in comparing the electrical characteristics of insulating oils, when made according to conditions discussed in Part I of this paper.

2. At higher frequencies and lower temperatures the conduction loss becomes small compared to an a-c. loss which may be qualitatively explained on the basis of Debye's theory of polar molecules. While it is true that Debye's theory has given qualitative agreement with observed data, it is possible that similar relations may be developed on the assumption of the motion of charged particles in an ionic atmosphere.

3. In mineral oils having lower-viscosity, but about the same conductivity, this a-c. loss is negligible at even lower temperatures and higher frequencies than for the more viscous oil.

4. For oils containing larger amounts of polar constituents, such as castor oil or oil-rosin mixtures, this a-c. loss may be appreciable even at commercial frequencies and temperatures.

5. Data indicate that it is dangerous to draw conclusions as to the characteristics of a material from measurements taken only for narrow ranges of experimental conditions. Studies over wide ranges of frequency and temperature may explain apparent discrepancies between results of different experimenters working within different limited ranges of measurement.

From "Some Electrical Characteristics of Cable Oils," (No. 31-47) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

Fundamental Properties of Impregnated Paper

By
J. B. WHITEHEAD
Fellow A. I. E. E.

W. B. KOUWENHOVEN
Member A. I. E. E.

Both of Johns Hopkins University, Baltimore

FIRST results are given in this discussion covering a study of the separate electrical behavior of the paper, the impregnating oil, and the combination thereof which constitutes impregnated insulating paper. Where possible, efforts were made to determine the relationship existing between fundamental and final characteristics.

The materials used constituted two essentially identical paper specimens and two oil specimens drawn from the same batch. The paper samples were carefully dried prior to testing; one of the oil specimens was used "as is" and the other was deteriorated by heating in the presence of air until its dielectric loss and conductivity were approximately double that of the other specimen. All specimens were tested separately; subsequently combinations of the paper specimens with the two different oil samples were tested.

Test procedure involved the use of both continuous and alternating potentials for the determination of temperatures ranging from 30 to 60 deg. cent. Short-time oscillograms and long-time values of charge and discharge currents were measured using continuous potentials; power factor, capacitance, and dielectric loss were determined with alternating potentials. All of the a-c. loss in the paper specimens can be accounted for by absorption, while the dielectric losses in the oils can be accounted for entirely by the short-time conduction and brief initial dielectric absorption.

The two impregnated-paper specimens were found to be alike, in that their voltage-power factor curves were straight lines and that their losses increased in proportion to the square of the test voltage. Some noteworthy differences, however, are worth mentioning:

1. The shape of the loss-temperature curve for the paper specimen impregnated with the poorer oil had a U shape, while the other showed a curve that was falling over the entire range of temperature studied.

2. Although initially both paper specimens had the same capacitance, the one impregnated with the poor oil of high conductivity and lower dielectric constant had a greater resulting capacitance than the other which was impregnated with the good oil of low conductivity, but of greater specific inductive capacity.

3. Dielectric loss in both impregnated specimens was greater than the sum of the individual losses in the paper and oil used in their production and may be completely predicted from the short-time continuous-voltage records.

4. Electrical characteristics of paper are changed by impregnation. The reversible absorption and the irreversible charging current both are increased by the conductivity of the oil.

The differences in the characteristics of the two impregnated specimens were due to the differences in the initial conductivity of the two oil samples. The dielectric loss in the specimens has been analyzed and separated into three components; reversible absorption, irreversible conduction current, and final conductivity. The loss due to short-time conduction may be as high as 30 per cent of the total loss, and 250 times the loss as computed from the final conductivity.

From "Fundamental Properties of Impregnated Paper," (**No. 31-45**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

Air and Moisture versus Paper Insulation

By
J. B. WHITEHEAD
Fellow A. I. E. E.

F. HAMBURGER, JR.
Assoc. A. I. E. E.

Both of Johns Hopkins University, Baltimore

THIS is the third of a series of studies into the still open question of the influence of residual air and moisture upon the properties of impregnated-paper insulation. The influence of residual moisture was found to be universally bad and increasing amounts of such moisture are immediately reflected in higher values of power factor and loss and in other evidence of instability. One of the most striking results of the earlier studies was the relatively small effect of residual air upon the shape of the voltage-power factor curves. The shape of these curves was not appreciably affected in the range of evacuation pressure from 1 to 10 cm. Hg. abs. and furthermore the curves were flat up to 300 volts per mil and 50 deg. cent. Only at impregnation pressures above 25 cm. Hg. do the typical rising power factor-voltage curves become evident. Upon dissection, dryness and gas voids always were associated with rising power factor-voltage curves, and apparently-excellent impregnation with the flat curves.

The present paper presents the results of studies of the influence of residual air upon the life of the finished insulation. The value of the pressure of evacuation and impregnation was used as a measure of the amount of residual air. The test sample consisted of a brass tube 1 in. in diameter and 4 ft. long upon which were wrapped 15 layers of 0.0043 in. manila cable paper 1

From "Residual Air and Moisture in Impregnated-Paper Insulation—III," (**No. 31-95**) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

in. wide. In all respects excepting certain modifications for strengthening the ends to withstand the higher voltages requisite for the accelerated life test, the sample was similar to that used in the earlier studies.

In view of the influence of residual moisture, all the samples were dried to the same standard value of d-c. conductivity before impregnation and then evacuated and impregnated at various values of pressure as a measure of their air content. The usual program in the accelerated life test was to start at 400 volts per mil, followed by 500 and 600 volts per mil at 1-hr. intervals, thereafter advancing to 600 and 650 volts per mil at 10-hr. intervals, followed by 700, 750, 800, 850 volts per mil for increasingly long periods. This program resulted in a life in the neighborhood of 12 hr. for the poorest specimens, but in several cases of better grade, the life reached a week and more without sign of distress at prolonged periods of 850 volts per mil. In these tests the temperature remained constant at 40 deg. cent.

A summary of the conclusions is as follows:

1. The life of impregnated-paper insulation increases steadily with a decrease in the amount of residual air.

2. For impregnating pressures above 2.5 cm. the life decreases rapidly with increasing pressure of impregnation. For pressures below 2.5 cm. the results show an increase of life of from 10 to 50 per cent between 2.5 cm. and 2 mm. impregnating pressure.

3. For impregnating pressures below 2.5 cm. normal variations in material and structure, particularly in the tightness of the structure, may offset the increased life due to decreasing the pressure of impregnation.

4. Cable compound deteriorates if it contains only a small amount of air, even though it is kept in sealed containers at room temperature. Air should be entirely excluded to avoid deterioration.

5. Flat power factor-voltage curves and the absolute value of power factor should not be accepted as indications of long life.

6. Power factor rise due to the initial application of voltage during a life test is indicated as a possible criterion of insulation life.

7. A very satisfactory type of sample and reenforced cable-end for accelerated life tests has been developed.

8. Narrow variations in the quality of both paper and oil may cause wide differences in the electrical characteristics and in the lives of the impregnated products.

Insulation Variability

By
M. C. HOLMES
Assoc. A. I. E. E.

West Virginia University, Morgantown

THIS paper constitutes a theoretical investigation of the effect of insulation variability in determining the breakdown voltage of systems containing large areas of insulation, or large numbers of units of insulation in parallel. It is based upon the idea that a failure in the insulation of a system, like that of a chain, depends upon the strength of the weakest part, or unit; and that the greater the number of units in a system and the greater the variability among the units the greater will be the likelihood of a failure. The analysis, therefore, makes use of the laws of probability which incidentally are more exact and of greater practical importance than is generally believed.

That the results of the investigation may be immediately applied and tested in engineering they are given in the form of two general equations. These two equations give in terms of two parameters either the breakdown voltage of a system or the number of failures to be expected. The parameters are (1) mean breakdown voltage and (2) variability of the units of insulation of which the system is composed, both determined from tests made on samples. The paper shows how the results may be applied to the special case of electric power cables for comparing the relative merits of different cables and for determining the factor of safety required to take account of the inherent variability of the insulation. A graphical method of analysis also is described which makes use of a special kind of graph paper called "probability" paper. In the case of cables the probability coordinate is changed from "per cent" to "failures per 100 miles of cable per year."

The two general equations, and the meetings of the symbols, are as follows:

$$F = N\left[1/2 - \operatorname{erf}\left(\frac{1 - E_o/E_a}{S}\right)\right] \qquad (1)$$

and

$$E_b = E_a\left[1 - S \,.\, \operatorname{erf}^{-1}\left(1/2 - 1/(2\,N)\right)\right] \qquad (2)$$

The first equation gives the number of failures F to expect in a system containing N units of insulation at an operating voltage E_o, the units being assumed removed from the system upon failure. The two parameters E_a and S may be considered as representing the quality of the insulation as regards resistance to rupture, E_a being the mean breakdown voltage of the units and S the coefficient specifying the variability of the insulation. The second equation gives in terms of the same two parameters the breakdown voltage E_b for a system of N units of insulation connected in parallel.

The symbol *erf* is an operator used to denote the Gaussian error function, the value of which may be obtained from tables similar to tables of sines and cosines. The symbol erf^{-1} represents the inverse operation just as the symbol sin^{-1} represents the inverse of *sin*. Values of $erf(x)$ and $erf^{-1}(x)$ may be obtained from tables, then, just as are values of $sin(x)$ and $sin^{-1}(x)$ The equations therefore are quite simple and easy to apply in spite of their formidable appearance.

The coefficient S, specifying the variability of the insulation, is calculated from the results of breakdown tests on samples. It is the standard deviation, sigma, expressed as a decimal fraction of E_a. Sigma is defined by the following equation:

$$\text{sigma} = \sqrt{\frac{\Sigma\,(\delta)^2}{n}} \qquad (3)$$

where $\Sigma\,(\delta)^2$ represents the sum of the squares of the deviations of individual breakdown voltages from their mean, and n is the number of test results considered.

The two equations are entirely general. Specific equations may be obtained from them and applied to all kinds of insulation, either in the form of continuous areas as in cables, or in the form of discrete units as in

From "Insulation Variability—Its Influence in Determining Breakdown Voltages," (No. 31-99) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

overhead transmission lines. In the former case N represents length of cable measured in terms of some standard test length; in the latter case, N represents the number of units of insulation under voltage stress, for example the number of strings of insulators along an overhead line. In the case of thin sheets of insulation N may be taken to represent electrode area; equation (2) then gives breakdown voltage as a function of electrode area as well as insulation variability. It therefore constitutes a distinct advance over the well-known equation of Milnor's which takes account only of the effect of area.

In the past too much attention has been paid to mean breakdown stresses or to the extremely high stresses exhibited by a few samples of insulation, and not enough to the question of variability. The present paper shows that the variability is at least equally important, and often is the *more* important because it is the strength of the weakest unit—not the mean strength of all the units—which determines the strength of the entire system.

Thermal Breakdown of Solid Dielectrics

By
P. H. MOON
Member A. I. E. E.
Massachusetts Institute of Technology, Cambridge

THE purpose of this paper is to correlate the work which has been done on thermal breakdown and to put it in a form in which it can be used by the electrical engineer in the calculation of breakdown voltage. Besides a treatment of the Fock theory, the paper includes the derivation of new formulas for breakdown of very thin and very thick samples and for internal temperature rise and current.

A startling fact brought out by this analysis is that before breakdown the internal temperature never rises more than about 10 deg. cent. above ambient temperature.

The three Fock tables of breakdown voltage are extended to cover a wider range of temperature and all thicknesses, and the results are put in several forms convenient for numerical calculations. Breakdown voltage hitherto has been calculated by a tedious cut-and-try process using all three tables. In the present paper this has been simplified and the results given in the form of new curves and tables, thus greatly reducing the labor required for breakdown calculations. Experimental data are presented to verify the theory.

From "The Theory of Thermal Breakdown of Solid Dielectrics," (No. 31-83) presented at the A. I. E. E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

Equivalent Circuits of Imperfect Condensers

By
C. L. DAWES
Member A. I. E. E.

W. M. GOODHUE
Non-member

Both of Harvard Engineering School, Cambridge, Massachusetts

IMPERFECT condensers usually are represented by equivalent electrical circuits consisting either of a pure capacitance and a resistance in series or by a pure capacitance and a resistance (or conductance) in parallel. Algebraic relationships existing among these circuit parameters are well known and commonly are used in dielectric study and electric circuit computations. For most dielectrics the equivalent series and parallel capacitances are essentially equal; in this paper examples are given where this is far from true.

The purpose of this paper is primarily to show quantitatively the application of these equivalent series and parallel circuits to composite dielectrics consisting of solid dielectrics and ionized gases in series, and more particularly to high-voltage cables having degrees of ionization varying from practically zero to very high values.

With a composite dielectric consisting of a slab of glass in series with a film of ionized gas the equivalent series resistance for the fundamental component of current varies with the current density and, so far as heretofore has been known, its characteristic was merely a curve more or less indefinite in character. In this paper it is shown that this characteristic is a definite and relatively simple function of the current density and that it has a maximum value which is readily computed from the constants of the composite dielectric.

The characteristics of high-voltage cables hitherto have been given in terms of equivalent series and parallel capacitance and in terms of equivalent parallel resistance. The equivalent series and parallel capacitances in most cases are practically equal; even for

From "Equivalent Circuits of Imperfect Condensers," (No. 31-74) presented at the A. I. E. E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

values of power factor as high as 12 per cent they differ by only 1.5 per cent.

The equivalent parallel resistance and conductance and the equivalent series resistance of cables having ionization hitherto have been expressed by curves which seemed to have had no analytical basis. In this paper, however, it is shown that such curves (with the exception of the region of successive ionization) can be expressed by relatively simple analytical equations; also the curves of the equivalent parallel conductance and equivalent series resistance can be analyzed into three simple component curves. Moreover, at the ionization voltage these curves rise rapidly to a maximum and then decrease more slowly. This maximum value and the voltage at which it occurs are readily calculated, being very simple functions of the characteristic cable contants. These curves also are shown to be very similar to the power factor curve and to differ from it by only a coefficient $C\ \omega$ that is nearly constant.

Thus this paper puts on a moderately accurate quantitative and analytical basis what hitherto have been merely cable curves having no apparent relationship to the inherent cable constants.

Equivalent series and parallel parameters of ionized gas films taken by themselves also are analyzed, with only the fundamental component of current considered. It is shown that the equivalent series resistance of such films may be expressed fairly accurately by a simple equation, and that the characteristic has a definite and sharp maximum which is easily computed.

Unlike cables, the equivalent series and parallel capacitance of ionized gas films differ radically from each other in value. At large current densities the value of the equivalent series capacitance may be as high as six times the value of the equivalent parallel capacitance. Hence the two cannot be assumed to be equal as with ordinary cables and other dielectrics. The equations for the characteristics of an equivalent series capacitance can be determined from the characteristic curves themselves, but thus far it has been found impossible to relate them to any fundamental electrical property of the ionized gas.

Oscillograms show that with a sine-wave voltage the current in ionized gas films consists largely of harmonics, particularly those of high frequencies. It is emphasized in the paper that these harmonics render ambiguous many of the definitions which hitherto have been applied to dielectrics. Also most high-voltage bridges measure only the fundamental component of voltage and current. Hence it is recommended that for simplicity both in definition and in measurements, quantities relating to ionized gas films shall be defined for the present with reference only to the fundamental component of the current and voltage waves.

Water Power Exploitation in Switzerland

Switzerland is one of the few countries fortunate in having at its disposal more water power than its inhabitants can use conveniently. Hydroelectric power now is supplied to 90 per cent of the total population and to 98 per cent of all municipalities.

SWITZERLAND'S topographic, geographic, and economic situation contributed to bringing about the early and extensive utilization of the country's electric energy, not only for its railways but for various industrial and other purposes requiring motive power, says Prof. C. Andreae, engineer E. P. F., former rector of the Federal School of Technology at Zurich and now director of the Royal School of Technology at Guiseh (Egypt), in an article published recently in *Swiss Industry and Trade.*

A marked industrial development has taken place during the past century in Switzerland due primarily to the growing inadequacy of agricultural products to provide for the maintenance of its ever increasing population. Switzerland possesses no coal mines. Its rivers and waterfalls, however, are a source of great natural wealth and their exploitation has become a vital economic factor.

The total amount of this natural energy is estimated at 6,000,000 kw. and is capable of producing an annual output of 20,000,000,000 kw-hr. At the present time only 1,550,000 kw. is being utilized, the annual production amounting to 5,968,000,000 kw-hr. Nevertheless, in 1925 consumption had reached 820 kw-hr. per capita of inhabitants, without exports; including the latter the total per capita output exceeded 1,000 kw-hr. As would be expected from these facts there are surprisingly few people in Switzerland who do not enjoy to some extent the benefits of electricity, statistics indicating that 90 per cent of the total population and 98 per cent of all municipalities are supplied with this commodity.

The total area of Switzerland measures only 15,990

Contributed by F. Dossenbach, director of the Official Information Bureau of Switzerland, New York. Not published in pamphlet form.

sq. mi., or about twice the area of the state of New Jersey. This comparatively small area, however, embraces great differences in altitude, the highest point being 15,200 ft. above sea level; the lowest, 646 ft. Consequently declivities are extremely pronounced and stream beds exceedingly abrupt.

Judging from these facts, the prevalent conditions for hydroelectric development would appear to be favorable and simple. Switzerland's hydrologic régime, however, is peculiar; although 60 per cent of the precipitation occurs during the five winter months (November-March) and only 40 per cent during the seven summer months (April-October), rivers and streams are high in summer and low in winter. This is because winter precipitation takes place generally in the form of snow and remains stationary until the summer months. Consequently the energy produced directly in winter constitutes only one third of that obtained during the summer.

An exactly opposite situation exists as regards consumption and demand. Maximum consumption during a winter day is about 120 per cent of the average daily consumption throughout the year; for a summer day, the maximum is about 80 per cent of the average. An economical exploitation of this natural energy then obviously necessitates some measure to compensate for the divergency between output and consumption. Among the various methods advocated, the system of hydraulic accumulation during the summer, when output exceeds consumption, has proved the most economical and enjoys the greatest popularity.

Similar to the situation existing in the mountainous regions of western United States, accumulation is effectuated by means of dams allowing for the retention of the water during the summer. Accordingly, plants are constructed in the vicinity of the Alps where small streams with high heads produce relatively large quantities of electric energy with comparatively little water. Some plants have been constructed also on the lower portions of rivers and streams to utilize directly the heavy summer stream flow. During the summer months, these plants supply practically all demands, allowing those situated in the higher Alpine regions to fill their accumulation basins in preparation for the annual low-water period.

Considered from economic and financial points of view, these groups of power plants are not all organized upon the same basis. The Swiss Confederation owns the plants which supply tractive power for the state railways only. A small number are owned by the cantons or municipalities while others are operated by private companies. The most important groups, however, are owned by "mixed companies." These are limited companies in which the larger portion of the stock is in the hands of the cantons or municipalities. This combination, wherein private capital cooperates with public effort, has given excellent results in the majority of cases.

What will be the largest "accumulation" plant in all Europe is now under construction on the River Aare at Grimsel Pass. It will have two basins with a total capacity of 91,600 acre-ft. The principal dam will be 361 ft. high. Water is to be utilized in three instalments, with a total fall of 3,940 ft., and the ultimate plant capacity will be 250,000 hp. At present only the first instalment which will aggregate 120,000 hp., is being built. The waterfall for this initial development will be 1,770 ft. high, and the rate of flow, 642 sec-ft.

An excellent example of Switzerland's rugged topography showing a train of the electrified St. Gothard railway approaching the huge Kerstelenbach viaduct. At the right may be seen the Amsteg hydroelectric plant with its three penstocks running down the mountainside

News
Of Institute and Related Activities

And Next— The Tahoe Convention

The program has been published (pp. 514-6 ELECTRICAL ENGINEERING, July, 1931) and circulated to every member of the Institute; committees have been as busy as the proverbial bees gathering proverbial honey; Tahoe Tavern beckons with special reduced rates; the majestic Sierra Nevada await; Lake Tahoe is ready; and prospective speakers are (or undoubtedly should be) practising before favorite mirrors. In other words, the stage is all set for a most attractive Pacific Coast convention at Lake Tahoe, California, during the last week in August.

As hinted before, the forthcoming events offer opportunities attractively unique in the variety of things those in attendance may do, in addition to participating in a good technical program. Just to mention a few, there's hiking, fishing, boating, swimming, golfing, and Reno. And then there is the fact that transportation rates from many points are the lowest that they ever have been. Last, but not least, there is the cordial invitation of General Chairman A. W. Copley (vice-president-elect) to "come and bring the family."

Kansas City is Host to October Meeting

The South West District No. 7 of the A. I. E. E. will hold a three-day meeting at Kansas City, Missouri, October 22-24.

Four technical sessions have been tentatively scheduled, the first of which will comprise papers on a variety of subjects: building-construction welding, relay operation as affected by wave form, pilot-wire relaying, computing currents in network loops, backfires in rectifiers, overvoltages due to the dropping of load, and surge tests on a distribution substation. The three other sessions will include papers on: St. Louis-Bagnell interconnection, communication, and transmission and distribution. At the interconnection session a three-reel motion picture of the actual construction of the Bagnell dam will be shown.

In addition to the foregoing technical program there will be two student sessions at one of which papers by the students will be presented.

Other features of the program will consist of entertainment, inspection trips, and recreation. These will be announced in detail in a subsequent issue of ELECTRICAL ENGINEERING, together with a full listing of the papers to be presented.

Officers, Delegates, and Members Hold Animated Sessions at Asheville

Following the plan inaugurated in 1930, the conference of officers, delegates, and members, held under the auspices of the Sections committee and the committee on student Branches, met on Monday and Tuesday afternoons, June 22 and 23.

The attendance of official delegates was larger than ever before; representatives included 52 of the 59 Sections, all of the ten District secretaries, and counselor delegates from eight of the nine Districts in which committees on student activities have been organized. Institute and Section officers, Branch counselors, and other members present brought the total attendance to about 110.

After a brief opening session on Monday afternoon, sessions A and B were held in parallel, Everett S. Lee, chairman of the Sections committee, presiding over session A devoted to Section activities, and Prof. W. J. Seeley, a member of the committee on student Branches, presiding over session B which dealt with problems concerning the Branches and enrolled students of the Institute. Tuesday afternoon was devoted to a joint meeting of the two groups to discuss subjects of common interest.

The topics in a conference program, which had been mailed to delegates and others in advance, are given in the following outline:

Monday, June 22, 2 p. m.

1. Opening of conference:
   Announcements by Everett S. Lee, chairman of the Sections committee.
2. Remarks by W. S. Lee, president.
3. Remarks by C. E. Skinner, president-elect.
4. Remarks by F. L. Hutchinson, national secretary.
5. Division into parallel sessions of Section and student Branch delegates and members.

Session A—Sections Meeting—Everett S. Lee presiding.

6. The Institute Membership—J. Allen Johnson, chairman membership committee.
   a. The licensing or registration of engineers.
   b. Establishing a high professional standing of engineers in civic and other affairs.
   c. How to create an interest in members of six or more years standing in transferring to the grade of Member or Fellow.
7. Conduct of Sections—H. H. Henline, assistant national secretary.
   a. Finding new material for officers.
   b. Types of programs and speakers; frequency of meetings.
   c. How to build up and maintain interest of members in sections by technical and entertainment programs, and social features.
8. Finances—A. C. Stevens, secretary, District No. 1.
   a. Financing of Sections and District meetings.
   b. Financing of Section contact with local engineering societies.

Session B—Student Branch and Enrolled Student Meeting—Prof. W. J. Seeley presiding.

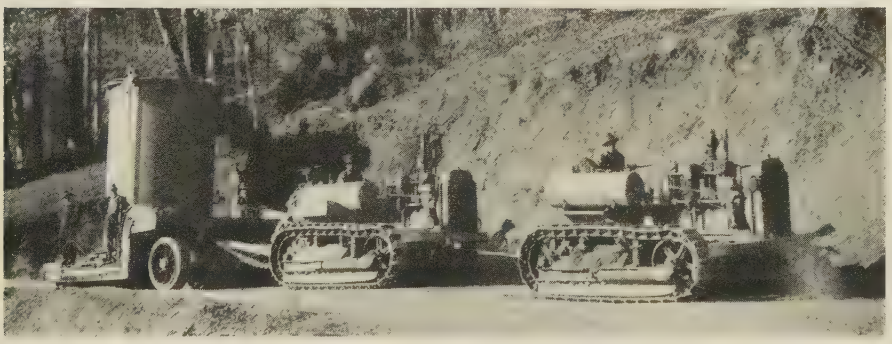
9. The problem of interesting the better high school students in electrical engineering—Prof. W. H. Timbie, chairman committee on student Branches.
10. The most advantageous time of year for holding student conferences—Prof. Joseph Weil, counselor delegate, District No. 4.
11. Coordination between the Branches and Sections, national organization, and practising engineers—Prof. G. H. Sechrist, counselor delegate, District No. 6.
12. Conduct of Branch business—Prof. G. L. Hoard, counselor delegate, District No. 9.
13. Financing the chairmen of the District student Branch committees—Prof. D. C. Jackson, Jr., counselor delegate, District No. 7.

Tuesday, June 23, 2 p. m.

Session C—General—Everett S. Lee presiding.

14. The Institute and the student—Prof. W. H. Timbie, chairman committee on student Branches.

Transportation in Electrical Construction



SINCE those in attendance at the Pacific Coast convention at Lake Tahoe, California, will have the opportunity to visit the recently completed Tiger Creek plant of the Pacific Gas and Electric Company on the Mokelumne River, it is of some interest to note the contrast in transportation facilities available for this latest job as compared with those available for the company's early De Sabla plant built on the same stream in 1904.

---

a. How to get the facts regarding the electrical engineering profession before juniors and seniors in high schools.
b. Cooperation between local Sections and student Branches.
c. Meetings of local Sections conducted by younger engineers.

15. General.
a. The extension of the scope of A. I. E. E. activities to include more of "the economic aspects of engineering" and "engineering views on non-engineering subjects."
b. Index of engineering literature as now published in **Electrical Engineering.** To what extent is it used? Should it be extended or condensed?
c. Questions and answers in general.

Copies of the annual report on Section andBranch activities for the fiscal year ending April 30, 1931 were distributed. These may be secured without charge to Institute members by applying to headquarters.

During the discussion on Section activities it was agreed that the Sections committee will consider the problems of such Institute members as are interested in a particular Section but located either in the territory of another Section, or outside the territory of any Section.

Recommendations Adopted

A resolution was adopted recommending to the board of directors that,

1. A national standing committee on transfers be created consisting of five members.
2. A local committee on transfers of three members be created in each Section.

The conference voted hearty approval of the recommendations of the committee on student Branches as reported by Chairman Timbie, for supplying information regarding electrical engineering as a career to high school teachers and students.

A motion was adopted recommending to the board of directors that the allowance of traveling expenses for visits of the vice-presidents to Sections and Branches in their Districts be increased is feasible, in order that a vice-president may be able to make many visits without incurring a considerable personal expense.

Decisions of the counselor delegates upon subjects not considered by the conference as a whole are summarized below:

The time of year at which District conferences on student activities should be held should be selected by each District according to its needs.

While some outside speakers are desirable, generalizing, the Branches should have very few.

The counselor of each Branch should instruct new officers regarding their duties and should insist that the Branch secretary report all meetings to headquarters.

The appropriation of $200 per year was recommended to defray the expenses of postage, stenographic service, etc., required by the chairmen of the District committees on student activities.

An abstract of the proceedings of the entire conference will be printed in pamphlet form and mailed to all delegates present; also to Institute, Section, and Branch officers. Any member of the Institute may secure a copy without charge by applying to headquarters.

"Slide Rule" for Lamp Calculations

As part of its development and educational campaign directed toward improved illumination efficiency, the Nela Park engineering department of the General Electric Company, Cleveland, Ohio, has issued recently a simple combination celluloid-and-cardboard slide rule. This device is designed to reveal the voltage-operating characteristics of electric lamps and to simplify the analysis of the economics of incandescent lighting. For any voltage condition the calculator makes easy the determination of the quantity of light that will be produced, the quantity of energy consumed, and the lamp life, thus showing at just what point the most light may be obtained for the least total cost.

With the improved quality of lamps now available, and the low prices prevailing, Nela Park states that generally the cost of current represents approximately 90 per cent of the cost of light under average conditions. Thus a variation of 1 per cent in lamp efficiency is as important as a range of 10 per cent in lamp price. The slide rule reveals quickly that operation of an incandescent lamp at slightly under voltage appreciably increases the lamp life, but also reduces lighting efficiency to a point which brings the total cost of illumination to a figure several per cent higher than would prevail if the lamps were operated at rated voltage. The lamp-characteristic calculator is available through the sales offices of the Edison Lamp Works and the National Lamp Works of the General Electric Company.

Summarized Review of Some Summer Convention Discussions

ONLY discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized; complete discussion together with all of the papers will be published in the TRANSACTIONS. The titles of the papers and the names of their respective authors were published in ELECTRICAL ENGINEERING, May 1931, pp. 370–1.

COMMUNICATION SERVICES FOR ELECTRIC UTILITIES

H. S. Phelps, in his discussion of this subject, stressed the importance of high quality of voice transmission on the part of the system devoted to the use of system load dispatchers. He explained also that considerable "transmission margin" should be provided to assure good communication in the event of system expansion or the emergency of rerouting communication circuits.

F. R. Innes discussed the use of a remote metering system, quickly responsive to changing load conditions, to communicate to one point and to one man a complete "picture" of the system load. Such a system would facilitate load division between stations and result in a more stable system operation.

ELECTRICAL MACHINERY

L. P. Shildueck discussed "Reestablishing Excitation of a Loaded Alternator in Parallel with Others," pointing out that to prevent damage to the rotor excitation should be reapplied as soon as possible. He analyzed the conditions resulting when a turbine generator upon loss of excitation runs as an induction generator above synchronous speed at some slip determined by the governor setting. At a condition of 2 per cent slip, rotor losses would be 1,500 per cent of normal and high body currents concentrated at the ends of the machine might burn the rotor wedges and cause considerable damage. For these reasons excitation and operation at synchronous speed should be reestablished very quickly; otherwise the machine should immediately be disconnected from the line.

L. L. Perry discussed this same paper with particular reference to the application of the facts presented to the triple-compound unit comprised of one high-pressure generating unit and two low-pressure units. In the event of accidental opening of the high-pressure generator field the prompt reestablishment of excitation (instead of opening the circuit breaker and admitting high-pressure steam to the low-pressure turbines) would result in considerably less momentary loss to the system and in quicker restoration of the load previously carried.

M. L. Henderson discussed "Calculation of Synchronous-Machine Constants," and analyzed the formula for end-winding leakage which he found yielded results comparable with those obtained by different methods. In conclusion he expressed hope that the nomenclature for machine dimensions, number of phases, number of slots, etc., used by different designers would arrive at a steady state. This would save a great deal of the user's time when comparing with the results of another writer.

H. Poritsky discussed "Field Transients in Magnetic Systems," and suggested an equally illustrative yet simpler example than the one given in the paper. In place of an iron core he suggests a yoke of width w considerably larger than the thickness t. A case is obtained which results in a one-dimensional problem in the heat equation, and from which the Bessel functions would be eliminated in favor of hyperbolic or circular functions.

AUTOMATIC STATIONS

M. E. Reagan discussed "An A-C. Supervisory Control System" and its proposal to use alternating current from the supply lines for supervisory control. This fact resulted in each case in the ultimate abandonment of similar systems proposed during recent years. He believed, however, that the system has several novel features which will tend to increase the reliability factor and that only time will give a true comparison to the storage battery systems.

F. H. Hollister read a discussion by T. G. Robinson on "Automatic Combustion Control," which verified the practise and results given in the paper. It also was explained that of late there has been a desire to eliminate multi-speed induction motors used to drive draft fans. This has led to the application of variable-speed Rossman drives for draft fans. Recent tests and analysis of one boiler installation in the Chicago area indicated an approximate 4 per cent overall increase in efficiency which corroborates the statement in the conclusion of this paper.

I. M. Stein also discussed this subject and made a plea that installations be kept as simple as possible rather than following the tendency to make them complicated just because automatic controls can handle complicated installations. He urged that station auxiliaries should be designed or selected with the requirements of automatic combustion control fully in mind.

M. C. Reagan discussed "Operating Experience with Automatic Control" with reference to the argument in the paper that in general, maintenance charts are not good for getting a complete, accurate record of operation. He believes that this may depend largely upon the type of form used. Some operators have found this to be the one method of obtaining good maintenance records.

One of the points discussed by C. E. Stewart in connection with this paper was the use of the mono-wire or direct-wire system. He believes that this system for short distances over privately owned wires is undoubtedly the most economical in first cost. Whether the sacrifice in flexibility to meet future rearrangement of the supervisory equipment due to changed operating conditions, future growth, etc., offsets this advantage is questionable and must be determined by local conditions. Maintenance of automatic equipment also was ably discussed by Mr. Stewart who pointed out that today more time is spent on preventative maintenance. Mr. Stewart also discussed miniature switchboards stating that considerable advance has been made in the design of suitable control keys and meters so that now the miniature switchboard is considered a standard type of board for installations in power and switching stations. They effect improved operating conditions and economies.

M. C. Reagan discussed miniature switchboards pointing out that the statement regarding increased intervals between maintenance periods corresponds to the experience of a great many operating companies. He cited that where equipment is kept in near-dust-proof cases, less maintenance yields better results.

SYMPOSIUM ON INTERCONNECTIONS

H. K. Sels discussed the papers presented in this symposium and in particular he would like to see the definitions in the paper entitled "Interconnection Services—Their Classification and Evaluation," accepted as standard. He pointed out that one engineer refers to "load diversity" where another calls it "peak diversity;" "economy flow" also is called "dump power." Furthermore, in contractual relations, accepted definitions would provide useful terms in writing contracts which would have a better legal status.

H. G. Harvey discussed the same paper saying that with a few very obvious modifications the main service divisions outlined in the paper could be applied to reactive kva. as well as to true power flow or kilowatts. In further discussion Mr. Harvey called attention to a momen-

tary emergency service caused by a surge originating on one system affecting the other. In some cases this condition has been a source of difficulty, and so far as is known no means have been devised to adjust for it equitably.

M. M. Samuels in discussing the same paper from the executive standpoint emphasized the importance of engineers submitting to executives economic answers rather than engineering answers. He cited and explained five items in systematic form which he thought should be presented to them for each year of each plan after the evaluation studies suggested by the author had been completed.

L. L. Perry in his discussion of "Interconnections" cited some of the advantages which accrue from the operation of widely interconnected systems, such as lower fixed charges, better operating economy, more uniform frequency, lessened voltage fluctuations, and better service reliability. He also expected that rapid developments with simultaneous automatic frequency-control equipment would be made, and he discussed the use of transformer phase-control equipment.

S. S. Seyfert called attention to the economic and social aspect of interconnections. He cited that the numerous interconnections already effected or in the making have created a new situation calling for a fuller degree of integration than now exists. If the public could be educated as to the advantages and attractive possibilities of interconnection and integration, and if the facts of which engineers are aware could be expressed in their own terms without technical language, the public would be influenced to stand behind and support integrated power systems, financially and otherwise, as they have done for other worthy projects in the past.

Interconnection—New England District

A. H. Sweetnam described several of the interconnections made with the Boston system. All important transformer banks involved in these interconnections now are equipped for tap changing under load and are supplemented by synchronous condensers. Phase-angle control equipment also is being contemplated. Particular emphasis was placed on one of the points mentioned in the paper: the importance (to the successful operation of any interconnection) of a mutual spirit of cooperation and good will regardless of formal contracts.

H. R. Kurth told of the operating problems of the Boston system in relation to its interconnection, and of some of the mutual advantages which accrue from such operation. Interconnections of ample capacity have permitted operation for maximum over-all economy of the several systems without loss of their corporate identities. In conclusion he stated that the spirit of cooperation between the several system operators is paramount in New England.

Electrical Units

H. B. Brooks discussed "Electrical Units and Their Application." He was in agreement with the author that electrical units should not be arbitrary if agreement with the fundamental units is to be maintained. He also told of a development by Doctor Silsbee to meet the demand in the a-c. field for a new type of instrument. It operates directly on the electrodynamic principle and can be wound as wattmeters, ammeters, or voltmeters, with a reading error equivalent to that of a pointer instrument having about 1,250 scale divisions.

In relation to the part of the paper pertaining to length measurement, H. W. Bearce calls attention to an important step taken in 1927 by the international committee on weights and measures by which a supplementary definition of the meter was set up in terms of light waves.

L. T. Robinson in his discussion of the subject expressed gratitude for the degree of precision attained by the Bureau of Standards in the absolute determination of the ohm. He hoped that some equally satisfactory arrangement might be made with regard to the volt.

H. L. Curtis in a discussion for Doctor Brooks summarized information which will probably be available to the international committee at its next meeting in 1933.

Standard Cells

L. T. Robinson commented on the fact brought out in Eppley's paper that the permanence of standard cells is much more satisfactory than their reproducibility in absolute values. If the absolute value of the ohm and the volt is adopted and if such progress is made with the volt as has been made with the ohm, the only requirement for working reference standards will be their permanence and transportability.

W. B. Kouwenhoven explained a simple, inexpensive, and fairly satisfactory method to reduce variations caused in standard cells by unequal temperature changes. They can be protected with heat-insulating material such as a two-inch layer of cork which gives good results.

H. B. Brooks discussed the use of standard cells and means of comparing them. He expressed favor for the opposition method, by which one actually measures only the small difference between the e. m. f. of the cell under test and that of the reference cell. He explained that he had under design a special potentiometer for standard-cell comparisons which is based on the opposition method but has novel features which avoid two small inconveniences of the method, mentioned by Doctor Eppley.

Design of Potentiometers

G. Thompson discussed the use of low-resistance and high-resistance potentiometers. He pointed out that it would be a mistake to draw the conclusion from the paper "Design of Potentiometers," by I. Melville, that the high-resistance potentiometer no longer has its place in voltage measurements; or even that it is inherently less accurate and reliable than the low-resistance types. Long experience has shown that gradual changes to take place in the resistance of the slide-wire, due to wear from the sliding contact near the ends of the wire. On the other hand, high-resistance potentiometers have retained their initial accuracy without repair.

H. S. Brooks discussed several points brought out in the same paper. He stated that absolute stability in the coils of a potentiometer is unnecessary; the requirement being that the various coils of any given potentiometer should maintain their relative values to a suitably high degree. In connection with taking account of parasitic e. m. f. by using a false zero setting of the galvanometer, as suggested by the author, he points out that there are cases, such as in the comparison of standard cells, where this method is not reliable.

Doctor Eppley discussed this paper and he believed the author had overestimated the difficulty of making 1,000-ohm coils constant to 0.01 per cent, and that he had underestimated the difficulty of making lower-valued coils of the same consistency. He said that he had known sealed 1-ohm coils, so enclosed as to be protected against humidity changes, action of oil, etc., to vary by more than 0.02 per cent; while on the other hand, he had checked many instruments having 1,000-ohm coils of the ordinary non-enclosed type which remained constant to 0.01 per cent.

N. E. Bonn in his discussion of this subject explained why he takes exception also to the author's discussion of the superiority of the low-resistance potentiometer over instruments having a high internal resistance. He also briefly discussed the modification of the White potentiometer shown in Fig. 6 of the paper. In calculating the maximum errors that may arise from the manipulation of dials and switches, he did not believe the author's assumption that compensation would always remain accurate to 0.01 per cent.

Cables

G. B. Shanklin discussed "Economics of High-Voltage Cable" calling attention to the fact that since the paper was written, there has been a still further reduction in the cost of 66-kv. oil-filled lines. This has been accomplished by a reduction of insulation thickness from 0.40 and 0.42 in. to 0.35 and 0.375 in., representing approximately a 25 per cent reduction in the cost of oil reservoirs, and an increase of from 70 to 75 deg. cent. in guaranteed maximum copper temperature.

W. B. Kouwenhoven discussed this paper with reference to the improvement in power factor with time shown in Fig. 31, and the fall in the ionization factor shown in Fig. 32. He explained that in his work improvement in power factor has been noticed following impregnation, which improvement continued over a considerable time before reaching a constant result. This was accounted for by a lowering of the initial conductivity of the impregnated material, possibly due to absorption of ions by the paper or to some other reason not understood.

W. A. Del Mar discussed this subject and called attention to several points made in the paper. With regard to the lower cost of 66-kv. single-conductor oil-filled cables as compared to the cables of the ordinary type, he pointed out that this conclusion applied only to the flat topography of Chicago. Concerning the simplification of oil-filled cable he believed that shipping-reel reservoirs for cables impregnated with liquid oil at the factory constituted an essential feature.

J. B. Whitehead in his discussion of this subject asked Mr. Roper whether credit for increased stability and life of the oil-filled type might not swing the comparison of the 66-kv. single-conductor cable more definitely to the oil-filled type and perhaps extend the economic oil-filled range even lower in the scale of load and voltage values.

Characteristics of Oil-Filled Cable

D. D. Higgins read a discussion of this subject prepared by K. W. Miller and F. O. Wollaston, which gave reasons why they preferred to solve the oil-flow and temperature-transient problem by well-known methods of elementary differential equations instead of the Heaviside operator used by the authors.

W. A. Del Mar discussed the papers on oil-filled cables and stressed the importance of the high dielectric strength over long periods of time rather than the "breathing" property, explaining how this was attained. In conclusion he indicated the two different methods used by the authors to obtain an open passageway between the reservoir and the hollow core without weakening the joint, and stated that the industry will watch with interest the performance of these two ways of solving the problem.

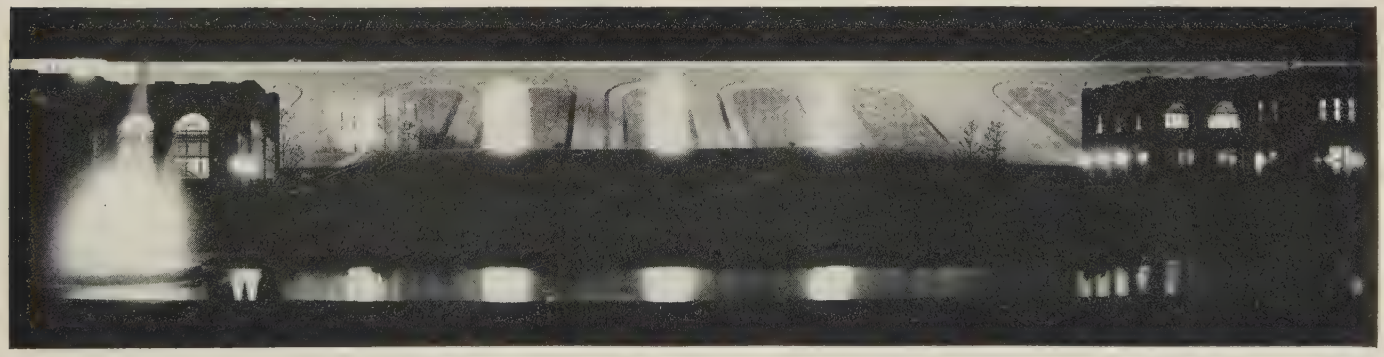
G. B. Shanklin discussed the condenser principle of joint and terminal designs brought out in the paper by Atkinson and Simmons. He believes there are undoubtedly possibilities in the use of this principle. However, to meet existing competition the designs must prove equally good, or better, electrically and mechanically and be of equal or lower cost. Compactness is an important factor to be considered. In his opinion, the condenser principle was more applicable to stop-joints than to normal joints and terminals.

Impregnated-Paper Insulation

G. B. Shanklin discussed the paper on this subject saying that he does not believe the results obtained could be reliably used as a practical guide for factory production methods. He is of the opinion that high vacuum during the drying operations is not the entire answer, as far as the removal of initial factory impurities is concerned.

A part of W. A. Del Mar's discussion in connection with this paper described an investigation made recently by J. H. Palmer showing by means of Lichtenberg figures the effect of corona on test voltage. The results as a whole did not show a definite increase in figure diameter with corona. Deviation from a mean was a maximum at the 60- and 80-kv. points, amounting to 0.04 "and 0.03" respectively, or 3 kv. If the very considerable amount of corona used in these tests had no appreciable effect on the voltage, the shortened cable lives noted by the authors

Spectacular Floodlighting at Wanaque Dam



THIS installation consists of 1,600 ft. of floodlighted dam with a slope of 210 ft. below which five electric fountains play, three of them 35 ft. high and 25 ft. wide studded in red, amber, blue, and green lenses and floodlighted by 36 underwater 1,000-watt projectors grouped twelve to a fountain and two smaller pool fountains 15 ft. high and 10 ft. in diameter, the red, blue, green, and amber lenses floodlighted by ten 500-watt underwater lamps. This is the recently completed Wanaque Dam of the North Jersey District Water Supply Commission, fronting eleven acres of attractively landscaped grounds, the roadway lighted with twelve 1,000-watt projectors effectively mounted on roof corners of the various buildings, the dam itself lighted with fifty 1,000-watt lamps mounted on pump house and service buildings to create an impressive appearance of the eleven massive arches silhouetted against the dark green of the brass beneath them and crowned with the white expanse of the main structure. W. T. Blackwell (A'22) general lighting representative of the Public Service Electric & Gas Company, Newark, N. J. was consulting illuminating engineer in charge for the Commission. (Contributed by G. S. Merrill (M'12) W. T. Blackwell (A'22) Public Service Electric & Gas Company, Newark, N. J., through the A. I. E. E. committee on the production and application of light.)

must be due to some kind of resonance effect.

W. A. Del Mar also read J. H. Palmer's discussion which described the design details of a cable terminal with a reinforced end having a logarithmic flare designed to withstand the higher test voltages.

E. M. Clark's discussion also was read by W. A. Del Mar; several suggestions were offered for consideration. A single stock sample of impregnating liquid of medium viscosity was used for several years, and no deterioration of liquid either in its chemical or physical or electrical properties has been noted. The liquid, however, was protected from light with no special precautions aside from the usual oil drum seal. It was suggested that the authors give further description of the physical and electrical characteristics of the compound which they have used.

H. S. Burd in discussion of this same paper pointed out that impregnation and vacuum pressures used would have to be quite different for cable manufacturing methods where large masses are concerned than where miniature apparatus and small samples are handled. He further indicated methods of improvement for the manufacture of solid types of cable paralleling the improvements in the oil-filled cable.

R. W. Atkinson discussed "Insulation Variability" pointing out that the paper has made the laws of probability conveniently available for use in the study cable insulation. However, in further discussion, limitations of the author's method of attack on practical cases were cited and errors in some of the assumptions indicated.

Research and Selected Subjects

D. C. Prince discussed "Extinction of Short A-C. Arcs" stating that no mention was made of some prominent arc characteristics, such as the rectifying effect of arcs in general and of metal-vapor arcs in particular. He described phenomena which should tend to explain the marked difference in behavior of low- and high-melting materials noted by the author. He believed the cathode-spot phenomena a predominant role in explaining the behavior of short a-c. arcs.

W. B. Kouwenhoven discussed "A Corona Tube Voltage Regulator" showing that the authors have described a voltage regulator which apparently is quite simple and without moving parts. He asked if it were possible to employ the system for the control of frequency, and requested the authors to give a complete circuit diagram, assuming the source of supply to be a 115-volt a-c. generator driven by a d-c. 230-volt motor.

R. H. Park discussed "Experimental Studies of Arcing Faults" commenting upon the method of measuring voltage. He claimed that with a potentiometer resistance of 500,000 ohms, the instrument itself might have an appreciable effect on the oscillations which develop during the arcing period. Thus the potentiometer may have prevented the occurrence of some of the phenomena which were under investigation.

J. K. Peck in his discussion of this same subject analyzed the results of some tests on a 140-kv. system. Out of eighteen oscillograph operations the highest overvoltages recorded varied from 1.2 to 2.6 times normal peak voltage-to-ground. In no case did cumulative oscillations appear in the voltages during the fault. Oscillation durations ranged from 4 to 112 cycles. A typical oscillogram of one of these faults was shown and it is believed that these records are a valuable supplement to the paper.

Cooperative Education

W. E. Freeman discussed this subject giving several reasons why it would be undesirable to apply such a system of education to state universities. As influencing difficulties he cited (1) large enrolments where engineering students are given fundamental instruction in other colleges of the university and (2) the usual small-community location of these universities, remote from industry.

S. S. Seyfert discussed the subject inquiring if the courses of the cooperative scheme could not be so planned that the two systems could be economically operated in parallel in a department of moderate size. He also asked about the difficulties encountered when a student desired to transfer from one plan to the other.

D. C. Jackson discussed the subject comprehensively and analyzed the value of the paper. So far as comparative results of the two plans are concerned, he pointed out that because of the many incomparables in the situation it is difficult to draw conclusions. He believes 25 years a suitable period to set up for observation in such educational matters before drawing full, ultimate conclusions.

A. I. E. E. Directors Hold June Meeting at Asheville

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at the Grove Park Inn, Asheville, N. C., Wednesday, June 24, 1931, during the annual summer convention of the Institute.

There were present: *President*—W. S. Lee, Charlotte, N. C. *Past-presidents*—R. F. Schuchardt, Chicago, Ill. *Vice-presidents*—H. V. Carpenter, Pullman, Wash.; H. P. Charlesworth, New York, N. Y.; H. S. Evans, Boulder, Colo.; T. N. Lacy, Detroit, Mich.; I. E. Moultrop, Boston, Mass.; W. S. Rodman, Charlottesville, Va.; G. C. Shaad, Lawrence, Kans.; C. E. Sisson, Toronto, Ont. *Directors*—A. E. Bettis, Kansas City, Mo.; F. C. Hanker, East Pittsburgh, Pa.; J. Allen Johnson, Buffalo, N. Y.; A. E. Knowlton, New York, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; E. B. Meyer, Newark, N. J.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y. *National treasurer*—W. I. Slichter, New York, N. Y. *National secretary*—F. L. Hutchinson, New York, N. Y. Also, present by invitation, were: L. T. Robinson, Schenectady, N. Y. *Assistant national secretary*—H. H. Henline, New York, N. Y. *Officers-elect*—C. E. Skinner, East Pittsburgh, Pa.; L. B. Chubbuck, Hamilton, Ont.; W. E. Freeman, Lexington, Ky.; B. D. Hull, Dallas, Tex.; W. B. Kouwenhoven, Baltimore, Md. *Past-presidents*—Dugald C. Jackson, Cambridge, Mass.; P. M. Lincoln, Ithaca, N. Y.; Charles F. Scott, New Haven, Conn.

The minutes of the directors' meeting of May 19, 1931, were approved as previously circulated.

A report was presented and approved of a meeting of the board of examiners held June 5, 1931, and upon the recommendation of that board the following actions were taken upon pending applications: 67 Students were enrolled, 117 Associates and 25 Members were elected, 35 applicants were transferred to the grade of Member, and five to the grade of Fellow.

Approval by the finance committee for payment of monthly bills amounting to $27,132.62 was ratified.

A progress report was presented embodying several recommendations of the special committee on Institute policies which had been appointed in accordance with action taken at the May meeting of the board of directors. (A statement regarding the functions of this committee was published in the July issue of Electrical Engineering.)

Upon the recommendation of the special committee on Institute policies and with the concurrence of Chairman Kidder of the committee on the engineering profession, a resolution was adopted "that in view of the large number of important matters that would ordinarily

come before the committee on the engineering profession, the work should be divided, and the name of that committee should be changed to 'committee on legislation affecting the engineering profession;' also that a new standing 'committee on the economic status of the engineer' should be appointed."

Consideration was given to the draft of a constitution prepared by the electrical advisory committee of the American Standards Association, for an "electrical standards committee," which was proposed by the A. I. E. E. in February 1930 to function as a joint agency in the electrical industry and as an integral part of the American Standards Association, for the purpose of carrying out the standardization activities of that industry. The board voted its approval of the proposed constitution.

The president was authorized to appoint a successor to the late Edward D. Adams as one of the Institute's representatives upon the engineering societies library board.

Recommendations to the board of directors adopted at the conference of officers and delegates held at Asheville, June 22-23, were presented and referred to appropriate committees for consideration.

Upon petition, and with the approval of the chairmen of the Sections and the finance committees, the board authorized the organization of a Montana Section of the Institute.

Consideration was given to a draft of a small pamphlet containing information on electrical engineering for high school students, to assist them in deciding whether or not to prepare to enter this profession, the board at a previous meeting having made an appropriation to cover the cost of printing. It was voted to approve the draft of this pamphlet for printing.

Resolutions were adopted expressing the board's appreciation of the services of the members of the Asheville convention committees; also extending to the newspapers of North Carolina appreciation of the effective publicity given by the press to the Asheville convention.

Other matters were discussed, reference to which may be found in this and future issues of ELECTRICAL ENGINEERING.

"American Bells" of Louvain in Summer Concert

The Louvain carillon, of French, English, and American fabrication, and rising 140 ft. above sea level, will celebrate a continuation of the international ceremony by which it was presented July 4, 1928, by a series of concerts during the summer, at which Kamiel Lefavere, Belgian cailloneur of the Riverside Church, New York will officiate. In a letter to Dr. A. D. Flinn, director of Engineering Foundation, Prof. Van Essen, secretary general of the University of Louvain has said, "These bells regulate our academic life as well as that of our citizens . . . through the University's office, they are governing the time-table and occupations of the whole city." Recent appointment of Paul Van Zeeland, professor of economics, University of Louvain, to the American Engineers Memorial Committee has been announced by the Hoover Foundation for the development of the university.

1931 Lamme Medal Nominations Close October 1

In fulfilment of By-Law requirements second posting is hereby given to the necessity of all nominations for the Lamme Medal for 1931 being submitted not later than October 1, 1931. (See ELECTRICAL ENGINEERING, June 1931, p. 446.)

Presentation of the 1930 Lamme Medal was duly made to W. J. Foster, consulting engineer, General Electric Company with suitable ceremonies at the opening session of the Institute's recent summer convention, Asheville, N. C.

Library of Congress Available for Wide Service

Collections of matter published in the various branches of science and available for public use in the Library of Congress, Washington, D. C., are far more extensive and comprehensive than seems to be generally understood, according to Dr. H. W. Tyler, consultant in science at that library. Facilities for research by both individuals and groups, a system of inter-library loans, and a card index service covering some 965,000 titles, are among the services available.

In addition to the strictly library service, according to Doctor Tyler there now are seven consultants: one each in science and philosophy, economics, and sociology; and three in literature and history. The function of these consultants is described as "interpretation," and assisting in forming outside contacts with specialists or various authorities in specialized fields. Engineers interested in the possibilities of using the Library of Congress service may obtain information relating to specific fields by corresponding with Doctor Tyler.

A. I. E. E. Lamme Medal Presented at Asheville

In keeping with the established custom the Lamme Medal of the American Institute of Electrical Engineers for 1930 was presented to Dr. William James Foster (F'16) at the summer convention in Asheville, N. C., with appropriate ceremony, Monday morning June 22, 1931. Instead of the custom previously followed of making the presentation in connection with an evening dinner meeting, this year it was made one of the first orders of business at the opening session, an arrangement in keeping with the importance and dignity of the occasion, and meeting with the heartiest approval of assembled delegates. As previously mentioned (ELECTRICAL ENGINEERING, March 1931, p. 230 and July 1931, p. 519) the award was made for Doctor Foster's "contributions to the design and development of rotating electrical machinery."

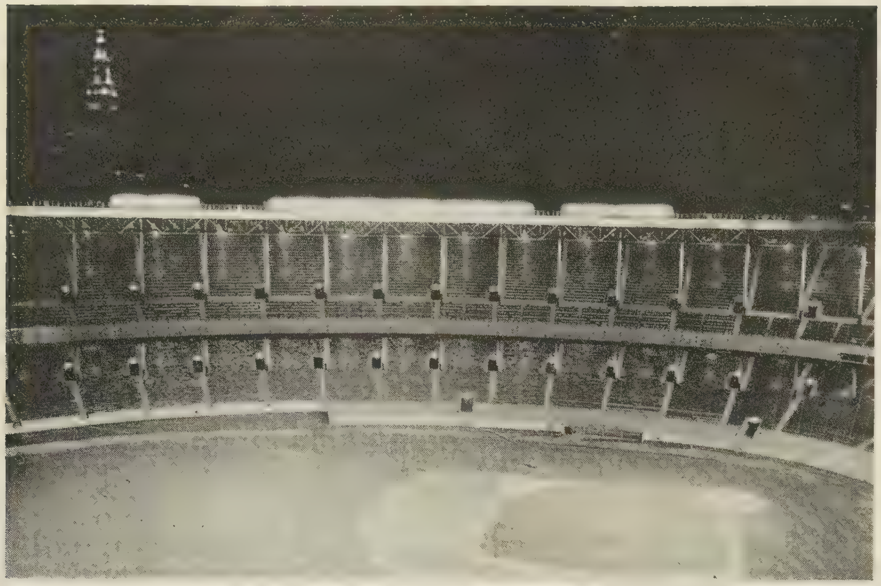
Past-President Charles F. Scott (F'25-HM'29) three-year chairman of the A. I. E. E. Lamme Medal committee and long-term active leader in Institute affairs, presided during the presentation ceremonies. Doctor Scott opened the meeting with a historical sketch covering the life of the founder Benjamin Garver Lamme, and his triplicate bequest to the A. I. E. E., to the Society for the promotion of Engineering Education and to the Ohio State University.

Doctor Scott introduced P. L. Alger, chairman of the A. I. E. E. electric machinery committee, who gave a biographical sketch outlining Doctor Foster's engineering achievements and paying him high tribute, saying, "No one has been more intimately and continuously associated with the development of large electrical machinery during its period of most rapid progress than has Dr. W. J. Foster."

Doctor Scott then called upon W. S. Lee, president of the Institute, to present the medal and certificate to Doctor Foster.

Doctor Foster in his response gave a brief outline of the history of rotating electric machines saying that while "it is possible that the art of designing rotating machines is nearing the climax I see no reason for not expecting still larger generating units. . . . However, it is probable that the outlook for real creative work now is in the line of motors rather than generators."

Cleveland's New Stadium Floodlighted



General Electric Co. Photo

CLEVELAND'S new $3,000,000 municipal stadium, said to be one of the country's best lighted sport arenas, is illuminated by 250 floodlighting projectors each equipped with a 1,000-watt incandescent lamp. These units are mounted along the stadium roof 110 ft. above the ground and arranged to give a normal average intensity of 20-ft. candles over the entire playing field with special provisions for intensities up to 50-ft. candles as required by different branches of sport. In the accompanying night view of one end of the stadium the tower of the new Union Terminal may be seen. Permanent seats are provided for 78,189 spectators.

Shall it be Price or Quality?

Because it reflects a serious condition that by no means is limited to the radio division of the field of electrical apparatus and appliances, and because electrical engineers well can afford to devote serious thought to the problems involved, the following editorial from the July 1931 issue of the McGraw-Hill publication *electronics* is reprinted herewith in full:

"The Blight of Price"

"Radio now faces a new internal competition—the bitter wrangle of price whittling—which is bound to manifest itself as a blight on every part of the industry.

"Former standards of quality are being abandoned in some quarters, in desperate efforts to get prices below competing low standards.

"Conservative factors of safety in set design and set manufacture are being wiped out, and the market is being flooded with receivers which 'just get by'—with prospects of troublesome breakdowns after a few months in the customer's hands.

"Tone quality—a requirement all important if broadcasting is to continue as a dominant musical medium—seems to have been forgotten, in the race to shave costs.

"All along the line, this blight of price is being felt, throughout the trade and industry, and in the associated fields of broadcasting and parts manufacture.

"Makers of components entering into radio sets find that their specifications and prices are being hammered down until price paralysis penetrates even the outermost fringes of parts making.

"Dealers and distributors protest that present low price units give them little on which to operate successful businesses. Broadcasters see the doom of their great new art, if poor radio reproduction is to be the standard,—rather than full fidelity of tone.

"Every group concerned deplores the price situation in which radio finds itself today.

"It is time the radio industry turned about and climbed out of this price morass. Every group is anxious to get back on good firm ground.

"Strong leadership will find an army ready to follow."

"Handbook of Oil Burning" Issued.—Information of practical value to the electrician whose work requires a knowledge of electrically operated oil burners is contained in the new "Handbook of Oil Burning" ($3.00) just published by the American Oil Burner Association, 342 Madison Avenue, New York, N. Y. Besides a thorough treatise on the part played by electricity in the operation of modern oil burning heating or power plants, the book discusses the different oil burner types and principles of construction, oil burner controls and motors, and the wiring of a house or building for an oil burner installation. A wealth of general information such as the fundamentals of heat and heat transfer, the chemistry of combustion and flame, the determination of heating capacity requirements, comparative fuel costs and like subjects is also included. Printed in pocket size for convenience, the new handbook contains 629 pages with 123 tables and 358 illustrations and charts spread over 24 chapters.

I. E. C. Plans for 1932 Paris Congress

The year 1931 represents 50 years of organized international electrical endeavor since that first convention in Paris in 1881, when the principal issue between nations whose delegates were in attendance was a decision on electrical units.

In a desire to make its 1932 congress in Paris particularly momentous the International Electrotechnical Commission has asked its United States national committee to appoint a subcommittee in charge of American participation in this congress. This special committee is now in process of organization; notice of personnel, detail of operation, etc., will be given publicity later. Until more complete plans have been perfected, all inquiries may be addressed to H. S. Osborne, secretary, United States National Committee, Room 1018, Engineering Societies Building, 33 West Thirty-Ninth Street, New York, N. Y.

Lamme Medal Award to C. A. Fieldner

The Lamme Medal award made this year at the Ohio State University was practically in duplicate; it being the first time the ceremony has taken place since the establishment of this special fund. The accumulated amount gave rise to a double presentation.

One of these medals went to C. E. Skinner, president of the Institute, (June, 1931, ELECTRICAL ENGINEERING, p. 524), and the parallel award was made, for like accomplishment—"for meritorious achievement in engineering or the technical arts"—to C. A. Fieldner, chief engineer, U. S. Bureau of Mines, Washington, D. C.

S. A. E. Meeting Discusses Novel Plans

With approximately 700 representative automotive engineers in attendance at its opening session, the summer meeting of the Society of Automotive Engineers convened at White Sulphur Springs, Va., June 14-19, "to solve problems of new designs and increase of production" in automotive industries. Fourteen technical sessions were occupied with subjects such as aircraft, automobiles, the evolution of the Diesel and other automotive engines, Diesel fuels, transportation, the investigation of detonation, the elimination of "vapor-lock," and results obtained by Bureau of Standards research.

Information on the new and unique "tear-drop" automobile body design was presented in a paper by W. T. Fishleigh, consulting engineer of Detroit, and discussed in some interesting detail. The Honorable D. S. Ingalls, Assistant Secretary of the Navy for Aeronautics flew to the convention in an autogiro to be the speaker Thursday evening, June 17, when Dr. G. W. Lewis, of the National Advisory Committee was presiding officer. A diversive program included a water carnival, field day athletics, flying, golf, tennis, archery, and a "grand ball."

Coffin Award Won by Virginia Electric.—The Chas. A. Coffin annual award to "the central station company which has done most for electrical art during the preceding year" was made in June in connection with the 1931 convention of the National Electric Light Association. This award established by the General Electric Company in honor of its founder, carries with it a check for $1,000 to be placed in the winning company's mutual benefit association. The Virginia Electric Light & Power Company received the honor for "increased efficiency of public benefit."

Rear-Mounted Automobile Engine is Predicted

Rear engine mounting for motor cars is a subject which is being seriously considered by the Society of Automotive Engineers. Placing the steering wheel in the center of an automobile and devoting most of the front half to the power plant seems absurd to Herbert Chase, a consulting engineer of New York, who pleads the case for this innovation: "Even a fairly long engine can be placed transversely at the rear of the chassis, and various cylinder arrangements are available that are not feasible for use under a normal hood in front, making the proportional length of chassis occupied by the engine much smaller than in conventional designs.

"Grouping all the mechanism at the rear gives the body designers a free hand; a streamline form becomes possible for the complete vehicle, parts such as lamps and spare tires being enclosed. Larger seating space, a better position for the driver, improved riding-qualities and a saving in weight are held out as objects to be gained by moving the engine from the front to the rear.

"Various forms and arrangements of the mechanical units are available, most of them calling for the engine, transmission and differential in a single, compact unit that is readily accessible and easily adapted for quick removal. Engine cooling and the control connections present two of the more difficult problems."

A. S. T. M. Announces New Officers and Activities

Announcement is made of the following officers of the American Society for Testing Materials for the year 1931: F. O. Clements, technical director, research laboratories, General Motors Corporation, Detroit, president; S. T. Wagner, consulting engineer, Reading Company, Philadelphia, Pa. vice-president; and A. W. Carpenter, manager, testing laboratories, B. F. Goodrich Company, Akron, Ohio, K. B. Cook, technical manager, Manville Jenckes Company, Pawtucket, R. I., J. B. Johnson, Chief, Material Branch, Material Division, U. S. Army Corps, Wright Field, Dayton, Ohio, G. C. D. Lenth, consulting engineer, Chicago, Ill., and O. L. Moore, engineer of tests, Universal Atlas Cement Company, Chicago, Ill., members of the executive committee.

The recently organized International Association for Testing Materials, (W. H. Fulweiler, United Gas Improvement Company, Philadelphia, American representative) holds its first congress September 6-12, 1931. Headquarters will be at the Swiss Federal Polytechnicum, Zurich, Switzerland, and the various countries represented by individuals and by companies will contribute to a technical program divided into four groups: (A) metals; (B) non-metallic organic materials; (C) organic materials; and (D) questions of general importance. Americans, all members of the A. S. T. M. and among them W. A. Slater, research professor of engineering materials, Lehigh University, W. A. Selvig, chemical engineer, U. S. Bureau of Mines, L. T. Work, asst. prof. chemical engineering department, Columbia University and H. F. Moore, professor of engineering materials, University of Illinois, will contribute papers the chief object of the congress being to secure international cooperation, and an exchange of views and experience in all matters incident to the testing of materials. Mr. Fulweiler may be addressed in care of his company or A. S. T. M. headquarters, 1315 Spruce Street, Philadelphia.

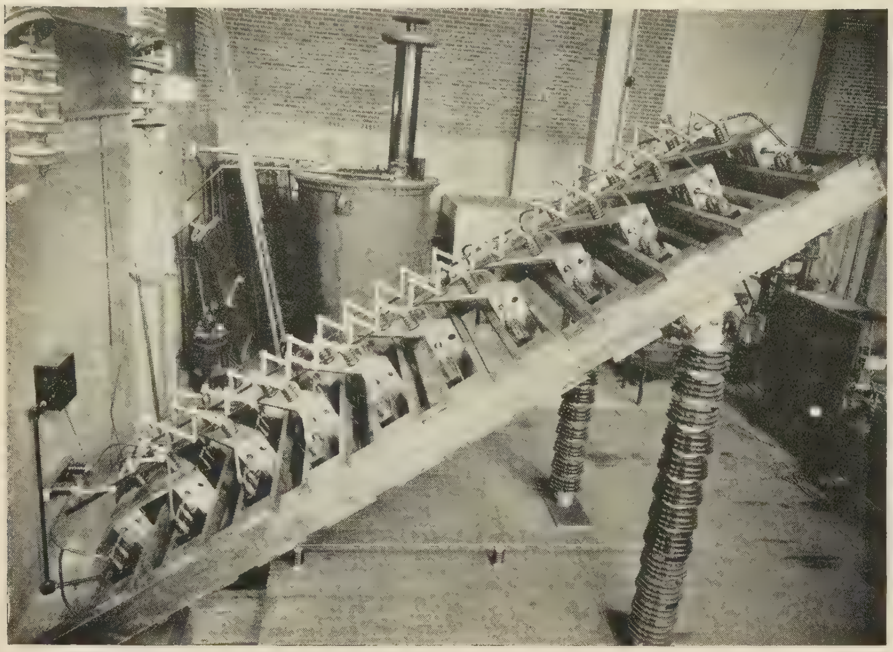
W. L. Saunders Comes to End of Active Life

William Lawrence Saunders, chairman of the board of directors of the Ingersoll-Rand Company, New York, and for most of his 75 years active in engineering and many other fields, died at Teneriffe, Canary Islands, June 25, 1931.

All his life he was ever watchful of opportunities to fill a breach or meet an emergency. As early as the year 1876 while on a newspaper in Philadelphia (perhaps an outgrowth of his having been editor-in-chief of the University of Pennsylvania Magazine, and class poet) he made two balloon ascensions to an altitude of several miles remaining up over night, an evidence of grit and initiative, as were also his courageous experiments in the development of his well-known equipment for rock drilling under water. A warm personal friend has said of him, "He wanted to be in everything, and he got there!"

He was president of his company at the time of its incorporation. During the World War, he was member and then chairman of the Naval Consulting Board, President Wilson giving personal recognition and appreciation of his work. He was past-president of United Engineering Society and of the American Manufacturers Export Association; a fellow of the American Geographical Society; member of the American Society of Civil Engineers, The American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, New York Chamber of Commerce, American Iron and Steel Institute, New Jersey Harbor Commission, and the National Foreign Trade Council; a director of two mining companies and president of *Compressed Air Magazine*. He was a prominent figure in the political life of the State of New Jersey and twice mayor of North Plainfield, his place of residence.

Lightning Generator at Purdue University



FOR studying lightning discharges and their effects upon electrical apparatus, this 1,000,000-volt lightning generator was placed in the engineering experiment station of Purdue University in June 1930. The 44 condensers are charged by subdividing them into eleven parallel groups of four each and applying a d-c. potential of 100-kv. through resistances of 200,000 ohms per bank. Charging potential is obtained from two 150-kv. 250-milliampere kenotrons, and can be varied by means of a full 100-per cent buck or boost regulator connected to the primary winding of the 5-kva. transformer supplying these tubes. The charging apparatus is remote-controlled from a push-button station, while discharge is initiated by a three-electrode and trigger-gap arrangement which makes possible also the synchronizing of a cathode-ray oscillograph with the discharge.

George Washington Bridge (N. Y.-N. J.) to be Well Lighted

Under an arrangement similar to that now in effect in the Holland Tunnel between New York City and New Jersey, the Public Service Electric and Gas Company (New Jersey) and United Electric Light and Power Company (New York) each will furnish half of the electric energy for illuminating the new George Washington Bridge across the Hudson River.

The new span will be lighted by 230 lamps (500-watt each) on 18-ft. standards spaced approximately 90 ft. apart on opposite sides of the roadways. Lights to be serviced by each company will be in staggered arrangement so that if one of the services is interrupted, half of the lights on the bridge still will remain lighted thus providing temporary illumination for the entire length of the roadway. Some 200 lamps (50 watt) suspended from up-stream and down-stream cables, will show these general curves so that at night aviators may avoid them. Because of the width of the roadway at the New Jersey approach, illumination of the bridge will be provided by floodlights mounted on the top of two 100-ft. ornamental towers. On the top of each of the two towers on the bridge there will be installed two Department of Commerce air beacons.

Societies' Library Reports on Service

In recent report, Harrison W. Craver, director of the Engineering Societies Library, states that during the first five months of 1931 there have been added to the library either by gift or purchase, 4,880 books and pamphlets. Of these, 3,030 have increased the main collection which now represents 66,527 titles indexed under 37,100 subjects with 434,326 cards and 135,574 classifications. The budget appropriation for 1931 is $56,653.55. Five months' service record is as follows:

Searches made	42
Articles translated	89
Books loaned to distant members	90
Members served by mail	1,561
Telephone inquiries satisfied	2,553
Number of visitors	12,255
Members served in person	18,726
Photoprints (to 2,136 persons)	21,691
Total, (books and pamphlets)	141,546

So far, the 1931 use of the library shows increase over the 40,000 engineers by whom it was used during 1930.

Dr. Karl T. Compton, president of the Massachusetts Institute of Technology was the recipient of the Rumford Medal, an award made by both the Royal Society and the American Association of Arts and Sciences "for the most important discovery and useful improvement in heat and light." Doctor Compton received it in recognition of his contributions in the field of thermionics by the study of electron emission from hot filaments, and in spectroscopics by the study of matter means of light waves.

Industrial Accident Statistics.—This 1931 edition of the booklet containing a record of injury rates in 28 American industries up to the year 1930, includes compiled from activities of electric railways, automobile production, construction, metallurgical operations and some other less technical occupations. It has just come from the press of the National Safety Council, Inc., 20 North Wacker Drive, Chicago.

Around the World with Light's Golden Jubilee.—An attractive and comprehensive "summary" by the International Committee on Light's Golden Jubilee, containing in alphabetical arrangement by name of country, some 70 pages of cuts and text illustrative of each country's share in this world-wide demonstration, has just come from the publishers. This souvenir booklet has been placed in the Engineering Societies Library, New York, that it may be of ready access to anyone caring to rehearse the pleasures and interest of this epoch-making event—"an extraordinary tribute to a great genius."

Dr. C. M. Slack, research engineer of the Westinghouse Lamp Company, by developing a glass bubble to be used as a window in the Leonard ray tube, won the $500 cash prize offered yearly by the Westinghouse company for "the most important changes either in manufacturing methods or design of a product of the company."

Standards

Graphical Symbols for Electric Traction Proposed

Pamphlet form of a standard proposed for "graphical symbols used for electric traction including railway signaling" (A. I. E. E. Std. No. 17g5) has just become available for suggestion and criticism. This report was prepared by a subcommittee of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations, working under the procedure of the American Standards Committee and sponsored by the Institute and four other organizations. Copies may be had without charge from H. E. Farrer, secretary, Standards Committee, A. I. E. E., 33 West 39th Street, New York, N. Y.

The report is limited to symbols for apparatus generally used for all classes of electric traction and railway signaling, for power houses, substations, transmission systems and distribution systems; electrical equipment of electrically-operated cars and locomotives; and electrical equipment and associated equipment used for railway signaling. In general, these symbols are intended for one-line diagrams of multi-phase a-c. systems, or on complete wiring diagrams of single-phase a-c. and two-wire d-c. systems. Where possible to have these symbols correspond with those in other reports and in other sections of this report, this has been done, but in some cases common agreement could not be obtained. It is hoped, however, that a period of use will bring them into complete harmony.

Engineering Foundation

Foundation Sponsors Publication Program

Initiated by a communication bearing the signatures of the presidents of the four Founder societies and the chairman of The Engineering Foundation, the latter organization has undertaken the publication of a series of articles dealing with various phases of the general subject "has man benefited from engineering progress." The first of these articles introduced by excerpts from the aforementioned communication appears on pages 641-4 of this issue of ELECTRICAL ENGINEERING.

The Foundation's stated aim in this noteworthy project is to "disseminate sound information among the millions of men and women who are vitally concerned" in the hope of "advancing the good of mankind by stimulating resourceful Americans to think their way through the passing months of maladjustment into effective action that will restore our normal state of steadily ascending happiness and freedom." To quote further:

"The Engineering Foundation has requested leaders of thought in many fields to state some of their observations of facts on the benefits which men of our times have obtained through the help of science and engineering. Their answers will be widely published with the intention of making them generally useful in these days when so many persons have had thrust upon their attention the problems of business, economics, social organization, and personal subsistence, which too many persons rarely consider seriously.

"The Engineering Foundation will welcome constructive contributions of additional information or comment from readers of the statements as they appear in newspapers and magazines."

Ambrose Swasey Gives $250,000 More

Another gift, of $250,000, from Mr. Ambrose Swasey (HM' 28) making his contributions total three-quarters of a million, has just been announced by V. N. Dorr, president of United Engineering Trustees, and H. H. Porter (M' 12) chairman of The Engineering Foundation.

At a dinner tendered by Chairman Porter at the University Club, New York, June 30, 1931, at which thirty presidents and former presidents of national engineering societies including the Engineering Trustees and The Engineering Foundation were present, together with other nationally prominent engineers, Mr. Swasey stated that in 1914 he became impressed with the thought that great and far reaching assistance might be rendered by a stimulation of research and development work in the engineering profession. Consequently he was inspired to work for the establishment of The Engineering Foundation, and now, "having a high appreciation of the very practical and helpful results already achieved and believing that the broad and well-laid plans of the Foundation promise even greater service in the future," Mr. Swasey generously makes possible the expansion of these activities by placing in the hands of the United Engineering Trustees this additional fund of $250,000 "for the furtherance of research in science and engineering or for advancement in any other manner of the profession of engineering and the good of mankind."

Mr. Swasey, now approaching 85, survives Mr. Warner in the Cleveland firm of Warner & Swasey, long famous for large telescopes, precision instruments, and machine tools. Doctor Pupin (President '25-'26) has stated that "had it not been for The Engineering Foundation it is quite possible that the National Research Council would not exist" and that therefore "several national problems which men in the united engineering societies, aided by The Engineering Foundation and guided by its ideals, can help to solve" would have had to remain perplexing obstacles to progress.

Personal

Dr. Harris T. Ryan Becomes Emeritus Professor

As of August 31, 1931, Dr. Harris J. Ryan (F'23 and past-president) retires from his long and successful career of active teaching at Stanford University, but in so doing he still retains the dual commission of emeritus professor of electrical engineering and honorary director of the Ryan Research Laboratory. This move is in accord with Stanford's established policy of relieving its professors of active class responsibilities upon the attainment of 65 years of age.

To those who have known and appreciated the diligence and attainment with which Doctor Ryan has labored for the profession, it is gratifying to learn that his plans for the future include a continuation of active research in the field of high voltage where he is looked upon as a worthy authority. For more than a decade his work has pioneered its way through obstacles in the path of electrical progression, and his realizations in connection with electrical application have eclipsed even the hopes of many men of science and the profession. In training his students for their specific work his principle has been always that any researches undertaken should be for maximum value to the engineer in the field; and in the founding (1926) of the Ryan High-Voltage Laboratory at Stanford University, reward for his untiring efforts, in the practical and consistent application of his principle was given concrete form.

His contributions to technical literature

are well-known; men of such organizations as the National Academy of Science, The American Physical Society, the American Association for the advancement of Science and others of similar importance representing science, engineering, and industry, have done him homage in friendship as well as in professional relationship. Doctor Ryan's whole career exemplifies fine achievement, cooperative spirit, cordial personality, and unusual ability of execution.

R. A. Millikan (M'22) whose discoveries in the realm of physics have made of him an international figure, has been named to return the visit of Professor Einstein. Only a short time ago Doctor Millikan was introduced to his radio audience by President Hoover, who designated him as "more than a physicist—one of America's leaders in philosophic thought." Recently also he was one of six notable physicists to receive first awards from a $1,000,000 trust fund established by Gustav Oberlaender, manufacturer of Reading, Pa., "to enable mature American citizens to study in Germany" and "increase understanding and good will between the people" of the two countries.

Ralph Kelly (A'12) southwestern district manager of Westinghouse Electric & Manufacturing Company, has just announced the appointment of L. S. Washington (A'19) as manager of the company's northeastern section, and that of E. D. Stewart (A'12) as manager of the southwestern section of his district. For the past several years Mr. Washington has been syndicate representative for Westinghouse in St. Louis and a member of the St. Louis Electrical Board of Trade. Mr. Stewart's new work gives him complete charge of company activities in the Houston, Dallas, San Antonio, and El Paso offices and respective territories.

C. L. Proctor (A'08) since 1925 vice-president and general manager of the Toledo Edison Company, an office which he holds also with the Lake Shore Power Company and the Toledo and Indiana Railroad Company, is now president of the east central division of the National Electric Light Association. He already has served in its midwest and southern divisions as a member of its executive committee. The Oklahoma Utilities Association and the Kansas Utilities Association also lay claim to him in like capacity.

J. A. Darling (A'21) assistant chief system operator, Edison Electric Illuminating Company, Boston, Mass. has been made chairman of the Operators' Association of New England. In token of his extended service with the company he was the honor guest at a complimentary dinner and the recipient of a 30-year service pin and Telechron clock with Westminster and Canterbury chimes from the Company.

H. E. M. Kensit (M'08) after 15 years in the Dominion Civil Service retired August 1, 1931, to enter private practise. Mr. Kensit is a member of the Engineering Institute of Canada and of the Association of Professional Engineers of Ontario. He joined the Institute in 1908 as an Associate but immediately advanced to the grade of Member.

C. H. Champlain (A'28) for the past eight years manager of the Westinghouse works at Sharon now has been made works manager at East Pittsburgh; while A. B. Raynders (A'07) in addition to his present duties as works manager, East Springfield, Mass., will assume supervision of operations at the Mansfield, O.

Charles M. Burrill (A'25) who has been broadcast receiver development engineer for the R. C. A. Victor Co., Inc., Camden, N. J., has gone to Ontario, Canada, to become research engineer for the Rogers-Majestic Corporation, Ltd. Mr. Burrill is 1930-31 chairman of the I. R. E. subcommittee on high-frequency receivers.

E. T. Moore (F'21) president of the Power Control Corporation of Syracuse, N. Y., is in Mexico where he will supervise the first installation of his invention the power demand limitator in a Mexican mine at Chihuahua. Later he plans to go to Mexico City, and thence to San Francisco, Los Angeles, Seattle, Salt Lake City, and points in Arizona.

W. M. Abbott (M'22) chairman of the board of directors of the Illinois Bell Telephone Company, on May 1, 1931, at the annual meeting of the Chamber held at Atlantic City received reelection as vice-president of the Chamber of Commerce of the United States for the Northern Central Division.

Frank Thornton, Jr. (F'21) manager of residence engineering, general engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been chosen manager of the company's association activities to succeed R. W. E. Moore (M'17) recently resigned.

Frank J. Meyer (M'17) assistant to the general manager, in charge of operation, Oklahoma Gas and Electric Company, Oklahoma City, Oklahoma, now has become its vice-president in charge of operation. Mr. Meyer is chairman of the Institute's Section in Oklahoma City.

Stanley Stokes (F'29) assistant vice-president of the Union Light & Power Company, St. Louis, Mo., has been appointed consulting engineer for that company and its subsidiaries. This new office will permit him to devote his entire attention to major engineering matters.

R. W. Allen (A'23) who has been acting in the capacity of distribution engineer for the South County Public Service Company, Westerly, R. I., recently accepted like position with the New England Power Engineering and Service Corporation, Providence, R. I.

G. F. Chellis (M'16) manager of Ferranti, Inc., New York, N. Y., has severed his connections with the American organization to accept a position with the Whitehall Securities Company, London, England, where he will be associated also with the English Ferranti Company.

Harry Reid (A'22) president of the National Public Service Corporation and the National Electric Power Company, New York, N. Y., and for more than 25 years prominently identified with electric light and power industries, now becomes vice-president of the N. E. L. A.

T. H. Morgan (A'23) has resigned from the office of assistant professor of electrical engineering, Stanford University to become head of the department of electrical engineering at Worcester Polytechnic Institute, Worcester, Mass.

H. T. Edgar (M'28) for the past 32 years associated with Stone & Webster in managerial work throughout the country as a division manager, after 45 years of service in the public utility field has resigned.

W. H. Bliss (A'30) graduate assistant in electrical engineering, Michigan State College, East Lansing, Mich., and designer and constructor of the "Telomat," is now instructor in electrical engineering there.

George Brock (A'19) draftsman for the Edison Electric Appliance Company, Pomona, Calif., has received promotion to the position of cost reduction engineer for his company.

Ralph A. Watson (A'08) consulting engineer of Champaign, Ill., is now on his way to Russia as consulting engineer for Arthur McKee & Company, of Cleveland, Ohio.

W. H. Taubert (A'29) has been placed in charge of sales in the insulation division of the Corning Glass Works, and is removing from New York City to the company's home office at Corning, N. Y.

Obituary

Edward G. Acheson, (M'88 and Member for Life) chairman of the board of the Acheson Oildag Company which he himself founded, died at the home of his daughter New York City July 6, 1931, of pneumonia. As a scientist and inventor he was known internationally and was the recipient of many medals and honors both here and abroad.

He was born at Washington, Pa. in 1856 and passed his youth in the manner of the average country boy, with no particular inclination toward the classics but a most pronounced fondness for mathematics. In his first position as time keeper at a blast furnace in Monticello, Pa., he was permitted considerable time for mechanical pursuits, and at the age of seventeen was granted his first U. S. patent on a rock-boring machine. The financial depression of 1874 closed the blast-furnace and Mr. Acheson was compelled to engage in non-technical labor until 1877 when he secured a position with the Alleghany Valley Railroad, which ultimately led to the work of tank gager in the Bradford oil fields. Irregularities of construction at that time greatly complicated capacity calculation, so Acheson promptly set about constructing a set of tables whereby the content of any tank could readily be determined. His efforts however did not meet with the approval of a superior whose business it was to calculate these capacities, and Acheson was dismissed. He entered the service of the Pittsburgh Southern Railroad as assistant to a surveying party; advances in electricity stirred his imagination and in a desire to become actively engaged in what was then a new industry, in 1880 he sought and obtained a position as draftsman with Thomas Edison at Menlo Park. Fortunately for him he was not confined closely to the drafting table but allowed to indulge his inventive genius and in 1881 he produced a graphite loop filament for the preparation of which he received the prize of $100 offered by Mr. Edison. Under date of January 8, 1889 he presented his first paper before the A. I. E. E. on the subject of *Lightning Arresters and a Photographic Study of Self-Induction.* Perhaps one of his greatest contributions to commercial science was his discovery of a new chemical compound produced electrically at the power plant of the Monongahela Electric Light Company which he founded in 1890. While working on the reduction of iron ore, he noticed that clay objects placed within the furnace became impregnated with carbon and as a result, much harder. Experimenting with similar clay-carbon mixtures, he produced a new chemical compound, silicon carbide, commercially known as carborundum. As it was hard enough to surface a diamond, it found ready market with jewelers and the Westinghouse company promptly placed a $7,000 order for 60,000 grinding wheels.

William F. Smith (M'27) assistant superintendent of power, Pacific Electric Railway Company, Los Angeles, Calif., passed away at his home in that city June 14, 1931. He was a native of the state of Missouri (1875) and was educated in the Santa Cruz high school and the correspondence school of Scranton, Pa. From 1894 to 1897 he was occupied with construction and operating work for the Santa Cruz Electric Railway; the next several years were engaged in construction and car house work. He was in charge of the installation of multiple-unit equipment of the North Shore Electric, Sausilito, Calif. and also reconstructed some operations of the Power Development Company, Bakersfield, Calif.; in fact most of his work has been construction and remodeling, including the Central Station of the Los Angeles Railway Company and all high-voltage work in all the stations of the Pacific Electric Railway. His Membership in the Institute dates from 1905, when he joined as an Associate.

Truman P. Gaylord (M'21) acting vice-president of Westinghouse Electric & Mfg. Company, with which he had been connected since 1900, died suddenly of heart disease at the home of his mother in Shelby, Mich., the place of his birth February 15, 1871. As a preparatory school for his later training, he attended the Allen Academy of Chicago, later to enter the University of Michigan, from which he was graduated with a degree in electrical engineering. In 1895 he secured a second degree from Armour Institute of Technology at which he held an associate professorship in electrical engineering 1894-98. The World's Fair at Chicago was starting and Mr. Gaylord engaged with the Fair company as engineer of underground construction, continuing in that capacity until 1893. From 1898 to 1899 he was engineer for the Chicago Edison Company, and July 1899 took his first position with the Westinghouse Electric Company. In 1902 he was appointed its district manager with offices in Chicago, a position which he occupied until he became acting vice-president, August 1914. By the board of directors of the Pittsburgh Chamber of Commerce he was recently elected president; also he was director and member of the executive committee of the Pennsylvania State Chamber of Commerce, and member of the United States Chamber of Commerce, the Duquesne Club of Pittsburgh, and the Pittsburgh Athletic Club. He was in charge of the radio division of the Westinghouse Electric & Mfg. Company, remained active and was apparently in good health up to the day of his death. He joined the Institute in 1902 as Associate.

H. G. Specht (M'23) consulting engineer for Westinghouse Elec. & Mfg. Company, Springfield, Mass., died May 17, 1931. He was a native of Farmsen-Hamburg, Germany (1876) and as a young man served several apprenticeships with German manufacturing interests, among them the Machine Company of Grotkast & Kespohl at Wandsbeck and the Electric Mfg. Company of Klamberg at Hamburg. During the

year 1896-97 he was in military service in the Engineering Corps at Berlin after which he studied mechanical and electrical engineering for two years at the university in Braunsweig, Germany. His next work was one of design for steamship and dredging machines in the city engineering department at Hamburg. Continuing his electrical engineering study, in January 1902 he graduated from the University in Karlsruhe with his E. E. degree. His work with Westinghouse dates from 1903, when he came to America and joined the East Pittsburgh office, where his work was chiefly test and the development of test curves in the dynamo test department. By 1905 he was designing special induction motors of all sizes and types. His paper *The Synchronous-Repulsion Motor—A Special Development for the Photophone* formed an integral part of the program at the North Eastern District meeting of the A. I. E. E. held at Springfield, Mass., May 7-10, 1930. His membership in the Institute was endorsed by such men as President C. E. Skinner, B. G. Lamme, C. F. Scott, P. M. Lincoln, and B. A. Behrend, all outstanding in the history of the Institute.

C. M. Rosewell (M'21) electrical engineer, Western Electric Company New York, N. Y., died at the Fairmont Private Hospital, Jersey City, N. J. June 2, 1931. He was 47 years of age and a graduate of the State University of Kentucky, from which he received his degrees in both mechanical and electrical engineering respectively 1908 and 1911. During the summer of 1908 he was operating engineer in charge of the plant of the Jackson Electric & Hydraulic Mfg. Company, Jackson, Ky.; the following year he spent in the test department of the Bullock Electric Company, Cincinnati, Ohio. From 1909 to 1913 he continued his test department work with the General Electric Company in Schenectady, advancing each year, from the test department to d-c. motor and generator design engineering, to central station engineering in the lighting department, to central station engineering and commercial engineering. In 1918 he was appointed engineer of the Appalachian Power Company in charge of practically all of the company's engineering. Bespeaking energy and ambition, while he was regularly busy during the week with other duties he engaged for special Saturday night service as night operator of the General Electric's power house switchboard; he also substituted for the superintendent at the Appalachian Power Company when that executive was off duty. He joined the Institute in 1919 as an Associate but in 1921 was transferred to the grade of full Member.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Bunce, Lewis I., Rocky Hill, Conn.

Cartwright, Kenneth C., Haig Hotel Annex, 2548 Prospect St., Cleveland, Ohio.

Cole, Will G., Box 222, Westwood, Calif.

Corriveax, F. M., General Electric Co., Schenectady, N. Y.

Deacon, L. O., 6 Ailsa Ave., East Malvern, Melbourne, Australia.

Haggerty, John J., 2849-33rd St., Astoria, N. Y.

McLean, James S., 190 Old Army Road, Scarsdale, N. Y.

Nuber, Frank J., 3831 Rokeby St., Chicago Ill.

O'Shea, V., Jr., 115 Broadway, New York, N. Y.

Pistorius, L. H., 193 Jeppe St., Johannesburg, South Africa.

Prudham, W. M., 100 Biddle St., Wilkinsburg, Pa.

Sullivan, John E., 6320 Kenmore Ave., Chicago, Ill.

Tung, C. T., c/o Stone & Webster Engg. Corp., Hopewell, Va.

Past Section Meetings

Portland Section Meets With O. S. C. Branch

The annual spring joint meeting of the Portland Section and the Oregon State College Branch was held at the college May 23, 1931; attendance 100.

Following a dinner, four technical papers were presented by students:

A Bridge Method of Testing Welds, by J. R. Batcheller.

Weld Strength as Indicated by Relative Conductivity, by Glen Barnett.

Influence of Preservatives on Dielectric Strength of Wood, by C. B. Parsons and M. H. Tiplon.

Moisture Content of Wood and Its Relation to Electric Permittivity, by C. E. Boucher and Hamilton Howell.

Cleveland

Annual dinner meeting at which W. S. Lee, president A. I. E. E., and consulting engineer and president, W. S. Lee Engineering Corporation, Charlotte, N. C., spoke on Doing a Common Thing in an Uncommon Way. Election of officers: G. A. Kositzky, chairman; F. E. Snell, secretary. May 21. Attendance 77.

Columbus

Rhythmic Ramblings through Our National Parks, by Dean Alfred Vivian, Ohio State University. Election of officers: W. L. Everitt, chairman; Roy Mallory, secretary-treasurer. May 28. Attendance 15.

Detroit-Ann Arbor

Golf tournament followed by dinner, Election of officers: Joseph J. Shoemaker. chairman; Raymond Foulkrod, vice-chairman; Oscar E. Hauser, secretary-treasurer. June 20. Attendance 43.

Kansas City

Annual banquet. The Inductive Relations between Power and Telephone Lines, by A. T. Campbell and C. C. Yates, both of the Southwestern Bell Telephone Company. Election of officers: George Fiske, chairman; R. M. Ryan, secretary-treasurer. May 29. Attendance 93.

Madison

Machines, by Prof. C. M. Jansky, University of Wisconsin. Demonstrations at the electrical laboratories followed this talk. Election of officers: Norman H. Blume, chairman; G. F. Tracy, secretary-treasurer. June 3. Attendance 44.

Toledo

Institute Affairs and Activities, by E. C. Stone, The Philadelphia Company, and vice-president, District No. 2, A. I. E. E. Election of officers: J. A. Dinwiddie, chairman; Max Neuber, secretary-treasurer. June 12. Attendance 34.

Urbana

Audible Light, by John B. Taylor, General Electric Company, Schenectady, N. Y. May 26. Attendance 200.

Vancouver

Dinner. Election of officers: G. R. Wright, chairman; C. Arnott, secretary. June 8. Attendance 25.

Worcester

Inspection trip through the Tewksbury substation of the New England Power Association. June 13. Attendance 20.

Past Branch Meetings

University of Colorado

TRANSMISSION CONSIDERATIONS IN CHAIN BROADCASTING, by R. C. Giese, American Tel. & Tel. Company., Denver, Col. May 20. Attendance 45.

Election of officers: Fred W. Cooper, chairman; Sidney Larson, vice-chairman; Wendell C. Spear, secretary, John F. Drescher, treasurer. May 28. Attendance 45.

College of the City of New York

Election of officers: Alexander Rosenberg, chairman; Robert G. Herzog, vice-chairman; I. E. Lawlor, secretary; L. Milstein, treasurer. May 28. Attendance 18.

Lewis Institute

Inspection trip through the Chicago office of the Western Union Telegraph Company. June 12. Attendance 18.

Southern Methodist University

Election of officers: J. V. Melton, president; M. P. Jones, vice-president; Porter Lindsley, secretary-treasurer. June 2. Attendance 8.

Washington State College

Election of officers: D. H. Olney, president; Howard Stingle, vice-president; G. C. O'Brien, secretary; G. Bliesner, treasurer. May 21. Attendance 17.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

ELECTRICAL ENGINEER, 1931, single, 22, available immediately. Desires position in any electrical line with opportunity for advancement. Salary moderate. Has had some experience in public address systems. Location preferred, New York vicinity, but will consider others. C-9432.

GRADUATE ELECTRICAL ENGINEER, 22, single, B. S. in E. E., 1931. One and three-fourth years of practical experience with leading elevator company. Desires position with manufacturing or utility company. Location optional. Excellent references. C-9474.

GRADUATE ELECTRICAL ENGINEER, 1930, single, six months on Westinghouse engineering course covering tests on switchboards, circuit breakers, regulators, motors, generators, etc. Nine months supervising telephone conduit and cable plant construction and telephone cable testing. Excellent physical condition. Desires permanent position with a good future. Location, immaterial. C-9158.

SALES EXECUTIVE ENGINEER, electrical and mechanical training. Seven years' sales experience in bearing field, three years' sales engineering in application of bearings to electrical, mechanical, and automotive fields, four years' in sales management, promotion, and distribution. Would like opportunity to develop or direct sales. C-5431.

PYROMETER ENGINEER, 25, christian, single. Graduate E. E., extension course of Columbia University. Five years' experience as field engineer for well-known manufacturer of industrial instruments. Experienced in construction, application, and selling of pyrometers and automatic valves. C-8647.

GRAUDATE ELECTRICAL ENGINEER, 24, single, B. S. in E. E.; midwest university. One year of G. E. Test. Will consider position offering engineering experience. Location immaterial. Available immediately. C-9451.

GRADUATE ENGINEER, executive and consulting. Degrees E. E. and M. S. in engineering. Licensed professional engineer, New York State; 25 years' electrical-mechanical experience, design, operation, maintenance of power plants, industrial plants, modern production and plant operation. Combustion and heating, air cooled gasoline motors, heat transmission. Available now. B-8170.

GRADUATE ELECTRICAL ENGINEER. B. S. in E. E., 1931, intends to study for M. S. degree at night; 21, single. Desires position in any electrical engineering field including radio or vacuum-tube work. Available at once. Location, New York preferred but not essential. C-9467.

ELECTRICAL ENGINEER, graduate A. I. T., 24, married; eighteen months large utility company previous to college; three summer vacations as laboratory technician for radio condenser manufacturer; one year in electrical maintenance for self. Excellent references. Will accept minimum living salary with reliable concern. Go anywhere except Russia. C-8668.

EXECUTIVE AND GRADUATE MECHANICAL-ELECTRICAL ENGINEER; twelve years' experience in public utility, industrial, and marine fields. Specialized in plant management, economic studies, organization, and power plant design and operation. During the last four years supervised the expenditure of $10,000,000 for public works projects. C-9416.

ELECTRICAL ENGINEER, technical college graduate, 35. Ten to twelve years' mechanical and electrical experience in power plants, substations, and transmission and distribution systems. Work includes G. E. Test and public utility engineering and operation. Desires position on operating staff of power company. Location, not particular. B-9782.

GRADUATE ELECTRICAL MECHANICAL ENGINEER, University Budapest, Hungary; 41, American citizen. Research and development engineer with largest electric companies along manufacturing and insulating electric conductors. Expert knowledge of sound recording. Besides English, speaks German, French, Italian, Spanish, Hungarian. Desires position where also linguistic knowledge useful. Location preferred, California. C-2505.

1931 TECHNICAL GRADUATE of mid-western college, B. S. in E. E. 24, single. One year student engineer on G. E. test. References furnished. Available on two weeks' notice. C-9497.

ENGINEER EXECUTIVE, B. S. degree. twenty years' experience in engineering, contracting, and purchasing. Desires permanent connection with large industrial company or as a local representative. Location, New York City. B-5050.

TELEPHONE ENGINEER, married, 33; eleven years' experience, installation, building, equipment, and traffic engineering. Specialist on automatic equipment problems. Experience covers all types of telephone equipment. In addition to English speaks Scandinavian languages, German, and Spanish. Location immaterial. C-9532.

MECHANICAL ELECTRICAL ENGINEER for mines, or plant engineer for steel mill or allied industry; 42 years old, technical graduate, twenty years' experience. B-8653.

TELEPHONE ENGINEER, 38, married, university graduate, Lieut.-Col.-Officers' Reserve Corps; eleven years Bell System equipment engineering, five years' varied experience in Philippines and Orient. Consider anything offering opportunity for advancement. Specially qualified in planning and supervising economical and efficient provision of customers' telephone facilities. B-9568.

ELECTRICAL ENGINEER, E. E. degree, 36, single, desires position with public utility or engineering concern requiring executive ability and an analytical mind. Fourteen years' experience covering engineering, design, and valuation of power plants, substations, transmission and distribution systems. Available immediately. Location preferred, East. C-9570.

WIRE AND CABLE SALES ENGINEER, graduate electrical engineer who has specialized in electrical wire and cable engineering. Fifteen years represented public utilities and consulting engineers writing specifications, supervising manufacture, expediting, inspecting at manufacturer's plants, supervising installations. Experienced cable engineer for technical sales department of wire and cable manufacturer. B-3625.

GRADUATE ELECTRICAL ENGINEER, B. E. E. degree 1930, 24, single. Eight months on Westinghouse course. Assignments covered motor apparatus testing and refrigeration development work. Desires position with manufacturing concern or public utility. Working knowledge of Spanish. Initial salary and location secondary to opportunity. Reference. Available on short notice. C-9428.

GRADUATE ELECTRICAL ENGINEER, 23, B. S. in E. E. 1929, M. S. in E. E. 1931 from Massachusetts Institute of Technology. General Electric Test experience. Experienced in the design of motors and generators. Available on short notice. Location immaterial. C-9559.

GRADUATE ELECTRICAL ENGINEER, 27, single. Seven years' experience in supervising and laying out of electrical construction work in various industrial plants and buildings. Desires position as superintendent or electrical engineer with contracting or industrial firm or municipality. Available at once. C-9553.

ELECTRICAL-MECHANICAL ENGINEER, 39, married. G. E. student course. Eighteen years' experience sequence-motor-control systems, industrial engineering, sales, patents, investigations and reports, machinery development. Prefers connection as industrial consultant or as sales engineer. C-9552.

GRADUATE of five-year cooperative school, 22, single, B. S. in E. E. in 1931. Eighteen months' experience in the installation and engineering department of a public utility. Desires a position in any electrical line with future and an opportunity for advancement. Available at once. Location immaterial. C-9545.

ELECTRICAL ENGINEER, graduate German technical institute, 31, single. Two and one-half years with German railroad camp in maintenance of rolling stock, two years' practical experience in repair work on freight and passenger cars with American railroad camp and two years electrical inspector. Desires position with railroad camp. C-9519.

ELECTRICAL ENGINEERING GRADUATE desires position as junior engineer with public utilities concern in power plant operations or as junior engineer with construction company specializing in power plant and transmission line construction. Has had two years' experience in power plant construction and operation. C-9406.

ELECTRICAL - MECHANICAL ENGINEER, 31, married, five years' experience with American concern telephone equipment sales in United States and South America, two and a half years radio, movietone, amplifying equipment sales and installations as branch manager in Central America for European manufacturer. Speaks and writes five languages fluently. References. Available immediately. C-9558.

GRADUATE of five-year cooperative school in electrical engineering, 24, speaks Spanish and English fluently, one-year study of production methods and five years' of street railway experience, desires position in any state or nation. Location immaterial. C-9002.

ENGINEERING GRADUATE, 39 years old. Broad experience in design, construction, and operation along both electrical and mechani-

cal lines. Willing to go to any location. Excellent references. B-5471.

ELECTRICAL ENGINEER graduated 1928, 27, married. Has civil engineering and over two years' Westinghouse test course experience. Location immaterial. Now employed by manufacturing corporation. Desires position with a future. C-9568.

ELECTRICAL ENGINEER, 1931 graduate B. S. degree in E. E. from the University of Illinois, 23, single, American. Six months' experience in the engineering department of Illinois Bell Telephone Company. Some experience Thyratron tubes, photoelectric cells. Desires position engineering company, consulting engineers. Location, anywhere in United States, Canada. C-9582.

ELECTRICAL ENGINEER, B. S. and E. E. degrees. Nine years' experience in development and production of static condensers for radio, ignition, and power-factor applications. Some work with X-ray and power-amplifier tubes and associated apparatus. B-9250.

ERECTING ENGINEER, 46, of broad experience in power plant construction, maintenance, and operation. Exceptional ability in the erection and wiring of switchboards, power plant auxiliaries, oil circuit breakers, and high-voltage outdoor substations. Available immediately. C-8702.

GRADUATE ELECTRICAL ENGINEER, age 28, married, with eight years' experience in industrial plant construction and maintenance; railway electrification; power plant design, estimating, and construction. Supervisory experience on construction and costs with contractor. Desires position with utility, manufacturer, or contractor, where ability to handle labor and produce results is a prerequisite. C-4428.

ELECTRICAL ENGINEER, B. S. in E. E., 1927, single, 20 months' experience in design and testing of fractional-hp. motors; two years' manufacturing experience. Familiar with a-c. and d-c. motor and control application. Desires electrical engineering work. Location, immaterial. C-9168.

TECHNICAL GRADUATE, 31, married, eleven years' experience on steam and hydroelectric systems as operator and system operator. Desires position as load dispatcher or system operator. Location, immaterial, but West Coast preferred. C-7267.

INTERNATIONAL OR DOMESTIC BUSINESS, university graduate, 31, thoroughly trained and experienced, seven years' engineering and business United States and abroad; export, power system planning, developments, reports, estimating, organizing; foreign languages, German, Spanish, some French. Desires connecting holding company or trade; will consider representing concern abroad. Available short notice. Personal interview desired. C-3534.

ELECTRICAL ENGINEER, university graduate, 36, married. Background of eight years' experience electrical testing in field and laboratory, also in erecting equipment. Additional three and one-half years' experience in testing and manufacture of radio tubes. Desires position with manufacturer or laboratory. Location preferred Metropolitan New York. Available now. B-8817.

ELECTRICAL-MECHANICAL ENGINEER. Executive. Twenty-three years' diversified experience as an engineer and executive in industrial plant equipment and operation. Particularly successful in present connection along lines of mechanical plant improvement and in obtaining employee cooperation through personnel training. Can refer freely to each connection held. C-7839.

GRADUATE ELECTRICAL ENGINEER, 31, single, eight years' experience, design, and construction of transmission lines, voltages up to and including 220 kv., outdoor and indoor high-voltage substation and distribution networks. Desires position in engineering or construction department of large utility or holding company. Location immaterial. C-3564.

GRADUATE ELECTRICAL ENGINEER, University of Wisconsin, 32, single. Three years' Westinghouse Test. Seven years' supervision, power plant and transmission line construction. Eight years engineer inspector, purchasing, writing specifications, and expediting. Desires position with advancement and opportunities. Location, immaterial. Available August. B-9661.

RELAY ENGINEER, university graduate, ten years' practical experience, thoroughly familiar with all relay applications and testing, short-circuit studies, stability calculations, and all problems connected with system disturbances. Moderate salary. Available at once. C-9291.

GRADUATE ELECTRICAL ENGINEER, 1930, single. One year's experience in test, design, and development of small fractional- and integral-hp. motors. Previous experience with public utilities. Now employed. Position must be permanent and promise a good future. Location a secondary factor. C-9590.

ELECTRICAL ENGINEER, college graduate, married, five years' electrical apparatus design, fifteen years supervisor, high-voltage overhead transmission and distribution lines, substations, estimating design and construction, test field experience. Nine years' practical machine shop. Desires responsible position. C-9257.

ELECTRICAL ENGINEER, 21, single, B. S. degree in E. E., Texas A. & M. College 1931, holder of government broadcast class operator's license. Two years' experience in radio work. Desires position in radio or telephone industries. Available at once. Will go anywhere. C-9588.

ELECTRICAL ENGINEER, 23, single, graduate of five-year cooperative course. Did electrical construction work during course. Desires position with power company, engineering, or contracting firm. Location immaterial; Midwest preferred. Available immediately. C-9586.

1928 GRADUATE ELECTRICAL ENGINEER of recognized university, 26, single. Wishes employment where the following engineering experience may be used to advantage. One year power company test experience, 20 months as special apprentice on large electrified railroad, six months' radio and telephone experience. C-9112.

GRADUATE ENGINEER, B. S. in E. E. from Northern college of cooperative type; 23, single; cooperative experience; six months' production engineering in radio division of Westinghouse; six months power, local cabling drafting, including student course Western Electric; one year student engineer at Weston Electric Instrument Company; excellent references; location immaterial; available two weeks' notice. C-9599.

ELECTRICAL DRAFTSMAN, DESIGNER, five years' experience, supervisory control, wiring diagrams, plant, pole-type metering equipment, building, factory lighting, power plant layout including contracts sales, etc. Experience covers fifteen years wireless telegrapher, a-c. and d-c. motors, generators winding, shop test, repair man for all electrical equipment, lineman, meterman, switchboard repair man, power plant electrician. B-8984.

EXECUTIVE ENGINEER, 31, unmarried, graduate of outstanding engineering institution. One year of postgraduate study and teaching with record in executive capacity. Experienced on communication engineering, telephone, telegraph, radio, sound, television, etc. Speaks several foreign languages. Location, immaterial. Available immediately. C-696.

ENGINEER, Stevens graduate, one and one-half years G. E. Test, with broad knowledge of transmission operation gained during five years with public utility operating in the foreign field, seeks new connection, either domestic or foreign. Would be valuable for the staff of general superintendent being mechanical engineer with electrical experience. C-9177.

GRADUATE ELECTRICAL ENGINEER, 25; two years' experience in power system operation, system planning and development; also experience in distribution and transmission engineering. Desires position in any location with public utility, or in any electrical line offering a future. Available upon short notice. References. C-9281.

ELECTRICAL ENGINEER, 23, single, graduate Georgia School of Technology B. S. degree in E. E., Cooperative Plan 1930; five years' experience railroad shops all departments during cooperative course; one year's experience electrical utility, all branches. Desires position with utility or manufacturing concern. Prefers Southeast. C-9292.

ELECTRICAL ENGINEER, 22, single, E. E. degree, 1929; M. S. in E. E. from M. I. T., 1931; twenty months G. E. Test course. Desires position involving electric design and development. Location preferred, East. Available immediately. C-9462.

GRADUATE ELECTRICAL ENGINEER, 31, married, with seven and one-half years' experience including: 2½ years as engineer with manufacturer's service shop, two years university instructor, two years responsible position in manufacturer's engineering department and one year as electrician on station construction. Desires position with manufacturer, industrial concern, public utility. Available upon short notice. C-1073.

SECRETARY ENGINEER, as assistant to major executive or for promoting publicity with progressive manufacturing or railway industry. Good correspondent. Alert, industrious, reliable, courtous, pleasing, yet forceful personality. Holds B. S. and E. E. degrees from leading institution. Two years' graduate work engineering, business administration. Six years' experience research, development and testing. C-930.

ELECTRICAL ENGINEER, recent graduate, 23, E. E. at Rensselaer Polytechnic Institute; desires engineering work with opportunity for advancement; would like work in communication engineering or radio-tube engineering fields. Location, New York City. C-9605.

Instructors

M. I. T. GRADUATE ELECTRICAL ENGINEER, 35, married. Six years' industrial and teaching experience in electrical engineering. Several years' private research and development work on own initiative. Good ability, integrity, and personality. Desires university teaching position for life work. Location preferred, Middle West or South. C-2826.

PROFESSOR OF ELECTRICAL ENGINEERING, 40, six years' successful experience teaching practically all branches electrical engineering, state school. Considerable experience power, telephone work. One year switchboard engineering department of Westinghouse. B. S. in E. E. and E. E. degrees. Preferred location Rocky Mountains, Pacific Coast States. Available school year 1931-1932. C-5021.

PHYSICIST, middle-aged, experienced in industrial research, supervision of research, executive work and teaching physics for engineering and other classes of students. Advanced degrees in physics from prominent American universities. Emphasis of electrical subjects in training and teaching. Stability and opportunity desired. Available upon short notice. C-7900.

SUPERINTENDENT OF DISTRIBUTION, 43, married, electrical and industrial management. Twenty years' electric utility operating experience in engineering, construction, operation, maintenance of distributing and transmission lines, substations, first-aid, and educational work. Has sufficient public utility operating experience to qualify for position of superintendent. Demonstrated record of executive ability. C-8411.

GRADUATE ELECTRICAL ENGINEER, 25, obtaining Master's degree in June, 1931, desires position as assistant professor or instructor in electrical engineering or as research engineer. Four summers' employment with large utility company. Two years' teaching experience. Has had experience with development of remote-control apparatus. Location, United States. C-8994.

GRADUATE ELECTRICAL ENGINEER, 24, two years' manufacturing experience. Desires position on university staff with opportunity to work on Master's degree. Available September. C-9157.

GRADUATE ELECTRICAL ENGINEER, 23, B. S., M. S. in E. E., desires position, instructor in engineering department of college, university. Has fundamental, practical knowledge d-c., a-c. circuits and machines. Can teach engineering mathematics, physics. Has had some experience teaching, two years research work obtaining degrees. Location, anywhere in United States. C-9214.

ELECTRICAL ENGINEER, 1931 graduate of Colorado University, desires position as a junior engineer, sales engineer, or instructor in mathematics or electrical engineering subjects. Has had eighteen months' practical work in electrical service and repair of power equipment prior to college. Location, Southern or Western United States. C-9241.

JUNIOR ENGINEER, 1930 graduate, B. S. degree in E. E., associate member of Sigma XI. Eight months' practical experience in research, design, and testing with large radio concern. Desires position as engineering instructor or in any electrical line offering a future. Eastern location preferred. Salary secondary to opportunity. C-9300.

ELECTRICAL ENGINEER, 28, A. B. E. E. 1926. Two years as emergency man, one year as engineering assistant with a New

York power company. Four years with a telephone company making studies of equipment and operating conditions and on service maintenance. Two years teaching mathematics in evening classes. References. C-9308.

ELECTRICAL ENGINEER, 1930 graduate, 22, single. One year on the Westinghouse student course. Desires position as instructor in electrical engineering. Available school year 1931-1932. References. Location, immaterial. C-9311.

ELECTRICAL ENGINEER, B. S. degree, married, with about fifteen years' successful experience in the design and construction of transmission and distribution lines. Some teaching experience. Employed at present. Desires position as instructor in electrical engineering subjects or physics and mathematics. Excellent references. Location preferred, Middle West or West. C-9339.

ELECTRICAL ENGINEER, 30, married. A. B. '22; B. S. in E. E. '24. (Harvard.) G. E. Test, transformer design, development and technical writing; experience in factory planning, has taught evening classes. Speaks German. Location preferred, East. C-9402.

ELECTRICAL ENGINEER, 1931 graduate from a southern technical institute, desires part or full time position as instructor in mathematics or electrical engineering, with the privilege of carrying graduate work. C-9415.

TEACHER OF ELECTRICAL ENGINEERING, 37, married. Thirteen years' teaching experience, many summers spent in practical work. B. S. in E. E. and E. E. degrees. Taught all E. E. subjects, as well as physics, electric thermodynamics, descriptive geometry, mechanical drawing. Sixteen months' general management large college radio station. Available immediately. C-9445.

ELECTRICAL-MECHANICAL ENGINEER, 1931 graduate with experience in central-station equipment testing. Desires position teaching in capacity of instructor or as research engineer to continue with education leading to Master's degree. C-9461.

ELECTRICAL ENGINEER, 22, single. E. E. degree, 1929. M. S. in E. E. from M. I. T., 1931. Twenty months', G. E. Test. Desires position involving electric design and development or as instructor in E. E. Location preferred, East. Available immediately. C-9462.

RECENT COLLEGE GRADUATE, B. S. in E. E., 22, single. Desires position with electrical concern or as instructor in mathematics and electrical engineering. Some maintenance experience. Location preferred, East. C-9496.

INSTRUCTOR, electrical engineer, 31, with nine years' experience with utilities, contractor, consulting engineer, and manufacturers, wishes position as instructor for electrical and mechanical engineering or drafting, mechanics, etc., in trade schools, high schools; speaks and writes German and French. Good references. C-4758.

ELECTRICAL ENGINEER, graduate University of Illinois, 1926. Two years' experience with Westinghouse Elec. & Mfg. Company, two and a half years with public utility in planning division. Available immediately. C-9381.

GRADUATE ELECTRICAL ENGINEER, Lehigh University, 1930, married, 25, ten months' engineering graduate student at Westinghouse, and 22 summer months with National Tube Company. Desires position with public utility of manufacturing company where analytical and research ability is prime prerequisite. Available upon two weeks' notice. Location, East or Middlewest. C-9395.

ELECTRICAL ENGINEER, graduate 1931, single. Three years' cooperative experience in public utility maintenance work. Four summers' experience in ice-cream industry. Desires opening offering steady work and possibility of advancement. Location and type of work secondary. Available at once. C-9418.

GRADUATE ENGINEER, B. S. in E. E., 1928, 25, single. Fifteen months' G. E. Test course, including six months in vacuum-tube department. Sixteen months' development engineering of electrical aircraft instruments, control devices, and naval ordinance control. Also some testing laboratory experience. Available at once. Location preferred, East. C-9483.

MECHANICAL-ELECTRICAL ENGINEER, B. in M. E. and E. E. and Master degree in E. E. General Electric Test. Fifteen years' broad experience teaching, research, development, designing, and manufacturing plant management. Position desired teaching mechanical, electrical, or industrial engineering subjects; or part time teaching and management of university plant. Location, immaterial. C-4440.

GRADUATE ELECTRICAL ENGINEER, B. S. in E. E. 1929, single, 24. Twenty-one months' Westinghouse Test on rotating machinery and control apparatus. One year of advanced physics at Carnegie Tech. night school. Desires position as instructor in engineering subjects. Eastern location preferred. C-8966.

ELECTRICAL ENGINEER, B. S. in 1929 from M. I. T. Desires connection to teach engineering subjects. Practical experience in the paper-making and insulated-wire business as an industrial engineer. Able to handle men. Locate anywhere. C-9331.

GRADUATE ELECTRICAL ENGINEER, 24, B. S. in E. E. Knowledge of design, construction of indicating instruments; also knowledge of electron tube. Two year cooperative course with Weston Electrical Instrument Corporation. (32 departments including shop, office, and engineering work.) Three years' industrial work before college. Available immediately. Location, United States, Canada. C-9585.

ASSISTANT PROFESSOR INSTRUCTOR, 39, Cornell graduate, two and one-half years' teaching experience; will bring to the faculty first-hand knowledge of the latest practise in industrial work. Thoroughly familiar with practical requirements for design and installation of mechanical and electrical equipment for industrial plants, power stations, and boiler houses. A-3702.

1929 GRADUATE ELECTRICAL ENGINEER, 25, single. Fourteen months G. E. Test course including thorough experience with illuminating equipment. Also experienced in electrical maintenance, construction in manufacturing plant. Desires electrical, illuminating engineering position with future manufacturing utility company, or teaching position. Prefers Middle Western or Eastern location. Available at once. C-9560.

ELECTRICAL ENGINEER, M. I. T. graduate, with practical experience in design, construction and teaching, author of reference books in electrical and mechanical engineering, is open for teaching position. Well qualified to take charge of engineering and general courses such as mathematics, physics, drawing practical electricity, etc., in vocational and preparatory schools. B-4022.

ELECTRICAL ENGINEER, with Master's degree, desires position of professor of E. E. at a progressive university. Age 34, married. Five years with large electrical manufacturer, three years teaching electrical engineering and four years electrical engineer of an electric utility company. Available upon reasonable notice. C-1118.

RESEARCH AND DESIGN OR INSTRUCTOR, transportation field, manufacturer operating company or technical school. Five years' experience Westinghouse Electric design, manufacture and installation of control apparatus for electric cars and trolley coaches, and research and development on transportation problems. Graduate, University of Wisconsin, 1926. Age 29, single, Protestant. C-9475.

GRADUATE ELECTRICAL ENGINEER, western university, age 26. Two years with public utility company, one year's experience assistant instructor in large university in E. E. department. Operating experience with electric railroad and two years' experience in engineering professional photography. Wishes location in engineering or teaching fields. Excellent references available. Location immaterial. C-9525.

ELECTRICAL ENGINEER, B. S. degree in E. E. 1925. Two years' experience switchboard design, two years' industrial control, two years' teaching experience. Natural talent for teaching. Desires teaching position in engineering college. Location preferred, Middle West or West. C-9577.

GRADUATE ELECTRICAL ENGINEER, class 1929, age 26, single, nine months on Westinghouse graduate student course, thirteen months on transformer design. Desires position in engineering department of public utility or instructor of electrical engineering and mathematics. Location, Middle West or East. Available upon short notice. C-9549.

ASSISTANT PROFESSOR OF ELECTRICAL ENGINEERING, three years' research training and advanced study. Two years' teaching experience. Background of American and foreign utility work. Research and patents in high voltage insulation. Specialties, hydroelectric generation, transmission, radio and communication theory, transients. Best references regarding health, personality, and teaching ability. Location, immaterial. C-9313.

ELECTRICAL ENGINEERING GRADUATE, inexperienced, but with a sincere interest in teaching as a career wishes a position as instructor in electrical engineering, mathematics or physics in college or technical school; mathematics or physics in secondary school. Age 26, single. C-9205.

MECHANICAL ENGINEER, Purdue graduate, many years' experience in boiler work from fireman to plant engineer and manager of boiler shop. Interested in opening with power company or engineering department of industrial company, or with plate or structural shop. Experienced business manager and executive. Will consider teaching mathematics or structural design. B-5551.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.	205 West Wacker Drive	31 West 39th St.
San Francisco	Chicago	New York
N. D. Cook, Manager	A. K. Krauser, Manager	W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge: repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

Membership

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before August 31, 1931.

Appel, I., New York City Board of Transportation, New York, N. Y.

Bagger, A. C., Commonwealth Edison Co., Chicago, Ill.

Ballantine, J. S., General Electric Co., West Lynn, Mass.

Banister, A. L., New England Power Co., Lawrence, Mass.

Bell, L. W., Southern California Edison Co., Ltd., Santa Monica, Calif.

Brandecker, F. A., (Member) U. S. Navy, Navy Yard, Mare Island, Calif.

Coleman, F. D., Montana Power Company, Billings, Montana

Gill, W. T. (Member) c/o Piedmont & Northern Railway Co., Charlotte, N. C.

Goodale, W. G., New England Power Co., Tewksbury, Mass.

Gradby, E. I., 1825 Norman Ave., Ridgewood, L. I., N. Y.

Haye, F., Industrial Electric Motor & Tool Co., New York, N. Y.

Hilts, H. D., General Electric Co., Schenectady, N. Y.

Holdrege, C. F., 1936 South 33rd St., Omaha, Nebraska

Knapp, L. G., c/o Montgomery Ward & Co., Inc., Chicago, Illinois
(Applicant for re-election)

Machiorlete, L., 648 Palisade Ave., West New York, N. J.

MacNaught, M. S., Hixon Electric Co., New York, N. Y.

Morgenstierne, C. C. M., Illinois Steel Co., Gary, Ind.

Munhall, W. F., 712 Filbert Street, Pittsburgh, Pa.

Norell, J. J., c/o Mrs. H. H. Smith, Middletown, N. J.

O'neill, W. J., 816 Central Ave., San Francisco, Calif.

Rhoades, C. O., General Petroleum Oil Co., Seattle, Wash.

Richardson, R. B., Mountain View, N. J.

Roberts, L. C., American Tel. & Tel. Co., New York, N. Y.

Shytle, D. E., Huntt Elevator Repair Co., Washington, D. C.

Sidler, P. R., Brown, Boveri & Co., Ltd., New York, N. Y.

Sleeper, C. L., Pacific Gas & Electric Co., San Francisco, Calif.

Stiegler, E. J., 663 The Alameda, Berkeley, Calif.

Swigart, J. I., Follansbee Bros. Co., Follansbee, W. Va.

Tompkins, H. K. V. (Member) Gulf Production Co., Houston, Texas
(Applicant for re-election)

Wagner, I. B., Lima Locomotive Works, Inc., Lima, Ohio

Weidlein, W. D., c/o Black & Veatch, Kansas City, Mo.

Wolfe, G. E., Lincoln Hotel, New York, N. Y.

Youngstrom, C. H., 451 West 47th St., Los Angeles, Calif.

33 Domestic

Foreign

Dordi, K. M. (Member) Tata Hydro-Electric Power Supply Co., Bombay, India

Kemeny P. (Member) Brazilian Telephone Co., Sao Paulo, Brazil, S. A.

Miller, W. J., c/o Ingenio Santa Fe, San Pedro de Macoris, Dominican Republican

Perry, F. R., Metropolitan-Vickers Electrical Co., Ltd., Manchester, England

Raghunath, N. V., The Indian Institute of Science, Bangalore City, South India

Roberts, F. W., Estler Bros., Ltd., London, Eng

Tatrey, S. S., Jalgon Electric Supply Co., Ltd., Jalgon, Bombay, India

7 Foreign

ORDER FORM FOR REPRINTS OF FULL PAPERS ABRIDGED IN THIS ISSUE OF *ELECTRICAL ENGINEERING**

(August 1931) Number	Author	Title
☐ 31-13	J. H. Blankenbuehler	An Improved Arc-Welding Generator
☐ 31-17	F. B. Bramhall	Telegraph Transmission Testing Machine
☐ 31-40	J. B. Whitehead	The Conductivity of Insulating Oils
☐ 31-41	K. K. Palueff	Effect of Transient Voltages on Power Transformers—III—Non-Resonating Auto-Transformers
☐ 31-45	J. B. Whitehead and W. B. Kouwenhoven	Fundamental Properties of Impregnated Paper
☐ 31-47	H. H. Race	Some Electrical Characteristics of Cable Oils
☐ 31-63	F. C. Hanker (Chairman Subject Committee on Grounding)	Present Day Practise in Grounding of Transmission Systems—Second Report of Subject Committee on Grounding
☐ 31-66	G. Sutherland and D. S. MacCorkle	Burn-Off Characteristics of A-C. Low-Voltage Network Cables
☐ 31-74	C. L. Dawes and W. M. Goodhue	Equivalent Circuits of Imperfect Condensers
☐ 31-83	P. H. Moon	The Theory of Thermal Breakdown of Solid Dielectrics
☐ 31-95	J. B. Whitehead and F. Hamburger, Jr	Residual Air and Moisture in Impregnated-Paper Insulations—III
☐ 31-99	M. C. Holmes	Insulation Variability—Its Influence in Determining Breakdown Voltages
☐ 31-124	H. H. Skilling	Tuned Power Lines
☐ 31M2	S. B. Clark	A-C. Networks in Portland, Oregon
☐ 31M3	C. F. Green	Electrical Solutions of Problems of Regular Scheduled Flight

*Members, Enrolled Students and subscribers are entitled to one complete copy of any paper abridged if it is requested within one year from date of its publication in Electrical Engineering. Thereafter a charge of twenty-five cents per complete copy will obtain.

Name..

Address ....

Please order reprints by number. ***Address*** **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at hte Engineering Societies Library, New York, during June are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

BUSINESS ADMINISTRATION. By W. Wissler. N. Y., McGraw-Hill Book Co., 1931. 897 pp., diagrs., charts, tables, maps, 9 x 6 in., cloth, $5.00.——An interesting, readable presentation of the various factors that affect the problems which confront the administrator of business enterprises. Money, markets, men, machines, materials and methods are examined, and their relations to each other are discussed. A critical inquiry into the nature and ends of business as a complex institution aims to show executives where business stands today and the line along which it is developing.

ELECTRIC CLOCKS. By F. Hope-Jones. Lond., N. A. G. Press, 1931. 261 pp., diagrs., 9 x 6 in., cloth, 12s. 6d.——A combination historical and technical account of the evolution of the electric clock. Starting with Alexander Bain's patent of 1840, the author describes and criticizes the efforts of successive inventors and illustrates the steps that have led to the highly accurate devices of today. Numerous diagrams add to the usefulness of the book.

HIGH-SPEED INTERNAL-COMBUSTION ENGINE. By H. R. Ricardo. Lond. & Glasgow, Blackie & Son, Ltd., 1931. 435 pp., illus., diagrs., charts, tables, 10 x 7 in., cloth, 30 s.—A thorough analysis of the scientific basis of design, based upon extensive research and experimentation. General principles, rather than specific designs, are discussed in this important work, which will interest every designer. This is a new edition of the second volume of the internal-combustion engine. The principal change is the addition of a chapter on the high-speed Diesel engine.

LOGIC OF SCIENCE. By Harold R. Smart. Lond. & N. Y., D. Appletón & Co., 1931. 237 pp., 9 x 5 in., cloth, 8 s 6 d.——A systematic discussion of the problems that lie on the borderland between science and philosophy, which endeavors to show what scientific concepts have to contribute to the philosophic problems of existence, value, mind and reality, and to apply the logical principles developed by philosophy to the discussion of scientific ideas. The aims and scope of natural science are examined, the relation of each science to its neighbors is shown, the emergence of the major problems is traced, and the proposed solutions are indicated.

METALLKERAMIK. By F. Skaupy. Berlin, Verlag Chemie, 1930. 60 pp., illus., diagrs., charts, 10 x 6 in., paper, 6-r. m.——This little book is the first to describe systematically the manufacture of articles from powdered metal by molding and sintering it. The preparation and properties of powdered metal and of articles made from it are first described generally. The manufacture of wire, sheet and molded articles from powdered tungsten, molybdenum, tantalum and other infusible metals is then treated. This is followed by a section on carbaloy and similar hard alloys. An appendix discusses some other possibilities of the process.

PRINCIPLES OF CITY PLANNING. By K. B. Lohmann. N. Y., McGraw-Hill Book Co., 1931. 395 pp., illus., diagrs., charts, maps, 10 x 6 in., cloth, $4.00.——Aims to give, in a single volume, an account of the whole subject of city planning. The elements and principles of the various branches are presented, and such general matters as the scope and importance of the work, its possibilities and the means of its accomplishment are discussed. City planning in the United States is stressed. Both the design of new cities and the improvement of existing ones are considered.

RELATIVITY. By M. Palmieri. Los Angeles, Cal., Forbush Publ. Co., 1931. 87 pp., 11 x 8 in., cloth, no price indicated. ——A brief non-mathematical presentation of the theory of relativity, intended for lay readers who wish to understand its principles and consequences.

DIE WERKSTOFFDÄMPFUNG BEI DREH- UND BIEGESCHWINGUNGSBEANSPRUCHUNG. (Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, Heft 335.) By O. Föppl and G. Schaaf. Berlin, VDI-Verlag, 1930. 27 pp., charts, diagrs., 12 x 8 in., paper, 4.50-r. m.—— Presents the results of an investigation of the damping properties of various metals when subjected to different stresses. Tests of each metal were made by different methods and compared.

JET-WAVE RECTIFIER. (Ingeniorvidenskabelige Skrifter, A Nr. 24). By J. Hartmann. Kobenhavn, Danmarks Naturvidenskabelige Samfund, 1931. 300 pp., illus., diagrs., charts, tables, 11 x 7 in., paper, price not given. (Published in English.)——This is a mechanical rectifier based upon a principle invented by Mr. Hartmann in 1907. Between the years 1919 and 1929 he was actively engaged in developing the apparatus for high-power rectification. We have here a detailed account of the work done during this period and of the results that have been attained, both experimentally and in practise. The rectifier is quite distinct in character from the mercury-arc rectifier but may be used for similar duties.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN GHH-KONZERN, Bd. 1, Heft 3, pp. 45-68, February 1931. Berlin, V.D.I. Verlag, 12 x 8 in., paper, 3-r. m.—— Four investigations are reported: the effect of surface condition upon the durability of various steels: a critical investigation of the standard method for dynamic tests; recent advances in welding and cutting cast iron and cast steel; and the measurement of fluids in motion by means of nozzles.

PATENT LAW for Chemists, Engineers and Executives. By F. H. Rhodes. N. Y., McGraw-Hill Book Co., 1931. 207 pp., 8 x 6 in., cloth, $2.50.——This book, written for engineers and business men, discusses the questions of interest to men engaged in technical and administrative work. The law of patents, the requirements for a patentable invention, the rights that a United States patent confers, and similar general matters are explained and illustrated by citations from court decisions.

INDUSTRIEÖFEN, v. 2. Bau und Betrieb. By W. Trinks. Berlin, V. D. I. Verlag, 1931. 398 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, 20-r. m.—— This is the final volume of the German translation of the valuable book on industrial furnaces, the original of which is well-known to American engineers.

ROYAL TECHNICAL COLLEGE JOURNAL, Glasgow, January, 1931, Vol. 2, Part 3, pp. 371-566, paper, 10 x 7 in., 10s 6d.—— Describes work in the fields of chemistry and engineering. Among the subjects investigated were the magnetostriction of overstrained materials, the transmission of heat in a fluid in turbulent motion, the rotating wheel with disk of constant stress ratio, pressure strains in non-circular drums, the influence of direct and shear stresses on the end constraints of curved bars, a standard of roughness for steam nozzles, torsional rigidity and web torque of crankshaft units and the effect of journal clearance, heat transmission coefficients for superheated steam, fuel pipe effects in mechanical-injection oil engines, the lubricating properties of mineral, vegetable and fatty oils, the wave form of the mercury-arc power rectifier, and the radiant efficiency and heat distribution of electric fires.

UNDERGROUND SYSTEMS REFERENCE BOOK. By National Electric Light Association. N. Y., The Association, 1931. 377 pp., illus., diagrs., charts, tables, 12 x 9 in., $4.00.——A number of leading American authorities has assisted in editing this description of accepted practise in the design, construction, and operation of underground systems of electric distribution. Cables and their insulation, conduit and manhole design and construction, cable installation, splices and terminals, cable operation, miscellaneous equipment and safety practises are discussed in detail. A bibliography of over 4,000 references is appended to the report.

ANNUAL SURVEY OF AMERICAN CHEMISTRY, vol 5, 1930. Edit. by C. J. West. N. Y., Chemical Catalog Co., 1931. 629 pp., diagrs., tables, 9 x 5 in., cloth, $5.00.——A concise summary of the progress in pure and applied chemistry made in America during 1930. This va uable review contains much to interest engineers, especially in the sections upon the X-ray examination of metals, the metallurgy of iron and steel, water, sewage, cement and concrete, coal, petroleum, gaseous fuels, and paints. The references to sources are very extensive and complete.

Selected Items From Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Alloys

MAGNETIC. Nickel-Iron Alloys and Their Application to Instrument Construction, F. E. J. Ockenden. *Jl. Sci. Instruments*, vol. 8, no. 4, Apr. 1931, pp. 113-117, 3 figs. Investigation into magnetic properties of nickel-iron series has resulted in production of new class of magnetic materials, these materials having characteristics which render them superior to more usual silicon steels when used at inductions of less than 5,000 lines per sq. cm.; composition giving highest possible initial permeability is very closely 78 per cent nickel, 22 per cent iron; magnetizing and core loss curves. Bibliography.

MAGNETIC—HIPERNIK. Permeability of Hipernik Reaches 167,000, T. D. Yensen. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 386-388, 8 figs. To give electrical engineer data from which he can judge or calculate relative advantages obtainable by using hipernik, representative curves are given for hipernik and for 4 per cent silicon iron.

Alternators

COOLING. Systéme de protection pour alternateurs ventilés en circuit fermé (Protective Devices for Alternators with Circulating Air Ventilation), E. Haveaux. *Science et Industrie*, vol. 15, no. 208, May 1931, pp. 220-222, 4 figs. Review of increasingly severe conditions that high capacity turbo-alternators have to withstand and reasons why closed circulation ventilation is more and more applied; deficiency of actual protective devices in event of accidental failure in supply of air cooling water; simple device adapted to Valenciennes power plant alternators which, while consuming no auxiliary power, automatically converts ventilation into open circuit circulation.

Arcs

On the Theory of the Mercury Arc, K. T. Compton. *Phys. Rev.*, vol. 37, no. 9, May 1931, pp. 1077-1090, 4 figs. Theory of heat balance at cathode is extended by introduction of accommodation coefficient of neutralized ions, by evaluation of all processes which absorb energy gained by electrons in cathode fall space, and by correction of previous assumption that fields sufficient to extract electrons will affect heat of neutralization of positive ions at surface.

Potential Drop and Ionization at Mercury Arc Cathode, E. S. Lamar, and K. T. Compton. *Phys. Rev.*, vol. 37, no. 9, May 1931, pp. 1069-1076, 4 figs. By means of movable Langmuir collector, potential, ion concentration and electron temperature were measured at various distances from stationary mercury cathode spot, at various arc currents; results indicated cathode drop of 10.0 volts, and small negative potential gradient beyond fall space which was more pronounced at larger currents.

Cables

SHEATHS. Cable Sheath Damage and Protection. *Nat. Elec. Light Assn.—Pub.*, no. 127, May 1931, 17 pp., 17 figs. 35 operating companies contributed information on operating experiences; recent trend is indicated toward use of combination of asbestos and cement fireproofing; corrosion damage by d-c. electrolysis due to stray currents is in most cases being effectively combatted; much corrosion has been found in "green" concrete ducts due to chemical action of hydroxides in cement; remedial actions are suggested.

UNDERGROUND. Oil Reservoirs and Accessories for Underground Cables. *Nat. Elec. Light Assn.—Pub.*, no. 119, May 1931, 12 pp., 19 figs. Companies using oil reservoirs in which air or gas is in contact with oil under pressure report satisfactory operation; various types of reservoirs manufactured have proved satisfactory; some companies have found some of bellows type reservoirs to have rather short, useful life; in few cases, accessories and fittings have become defective in service.

Circuit Breakers

Fundamentals the Essence in Circuit Interruption, J. D. Hilliard. *Elec. World*, vol. 97, no. 18, May 2, 1931, pp. 809-811, 1 fig. Phenomena in oil circuit breakers are admittedly complex, but clarity will result if fundamental happenings in all types of breakers are segregated from those which make one type behave differently from another and even one model from another of same general type; much of confusion surrounding subject of circuit interruption results from failure to recognize common elements of all methods of circuit breaking as distinct from factors introduced by variations in design.

The Expansion Circuit Breaker, F. Kesselring. *Elec. Rev.*, vol. 108, no. 2791, May 22, 1931, pp. 859-861, 12 figs. Underlying principles; characteristic curves showing breaking distance; abiadatic expansion; entropy; saturated water-vapor pressure temperature; circuit rupture oscillograms; transportable wall-mounting, and outdoor types of expansion circuit breakers; illustrated comparison as to size between expansion and oil breaker chambers.

Conductors

IRON AND STEEL PLANTS. Conductors of Heavy Alternating Currents, D. I. Bohn and H. W. Pabst. *Iron and Steel Eng.*, vol. 8, no. 6, June 1931, pp. 253-256, 7 figs. Design data and curves for heavy a-c. conductors in steel mills; it is desirable to limit conductor temperature rise to 3 deg. cent., largely to assist in maintaining reasonable temperatures of connected equipment; pipe size of tubular copper and aluminum conductors with capacities for 30-deg. cent. rise at 60 cycles; channel conductor ratings for pairs of aluminum channels arranged to form square, temperature rise 30 deg. cent. over 40-deg. cent. ambient, at 60 cycles.

Dielectrics

Dielectric Properties of Matter, S. O. Morgan. *Bell Laboratories Rec.*, vol. 9, no. 10, June 1931, pp. 462-469, 7 figs. Molecular study, it is shown that methane is symmetrical and therefore non-polar; that in non-polar molecule centers of opposite charge coincide, in polar molecule they do not; potential applied to polar substance tends to shift its molecules from their random orientations; tetrachloromethane is symmetrical and therefore non polar, etc.

BREAKDOWN. Breakdown Voltage as a Function of Electrode Area and Dielectric Homogeneity, M. C. Holmes. *Franklin Inst.—Jl.*, vol. 211, no. 6, June 1931, pp. 777-779. If number of samples of insulation, all apparently similar as regards composition, thickness and area, are subjected to breakdown tests made under identical test conditions, they will not all fail at same value of voltage but, due to inherent inhomogeneities in composition of individual samples, will show variations in breakdown voltage; number of tests made in samples of unit area; voltage distribution of results represented is analyzed.

Education

ILLUMINATING ENGINEERING. Educational Training in the Lighting Art, P. S. Millar. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 5, May 1931, pp. 415-423. Paper was prepared at request of committee which organized present symposium on training for lighting work; it puts forward writers view that scope of lighting art is so broad that it requires of successful practitioner, a comprehensive acquaintance with fundamentals of science and of art with broad cultural background; without discussing in detail procedure in lighting education, it offers suggestion that models may be employed advantageously in such training.

Electric Drive

IRON AND STEEL PLANTS. Electrical Auxiliaries in Steel Mills, D. W. Dean. *Iron and Steel Engr.*, vol. 8, no. 6, June 1931, pp. 199-203, 9 figs. Successful steel plant of future will be one that maintains well planned program for improvements in their auxiliary drives, as well as for their main drives below 30 hp.; matter seems of minor importance, but when we consider that total investment in electrical auxiliaries usually exceeds total investment in main drives it becomes apparent that careful consideration is justified.

How to Get the Most Out of Control in Steel Mills, P. B. Harwood. *Maintenance Eng.*, vol. 89, no. 6, June 1931, pp. 294-296, 3 figs. Requirements for maximum service are select control designed to meet conditions of installation; apply proper motor and control for drive; install equipment properly; maintain it adequately.

LOOMS. The Individual-Motor Loom Drive as Viewed Today, W. A. Mayor. *Textile World*, vol. 79, no. 24, June 13, 1931, pp. 32-33, 3 figs. Advantages of individual drive.

OIL WELL PUMPING. Electrical Installation of Motors and Transformers, E. L. Spaugh. *Oil Weekly*, vol. 61, no. 4, Apr. 10, 1931, pp. 39-41 and 44, 5 figs. Notes on equipment of Rio Bravo Oil Co., in Guffey, Humble, Luling, Pierce Junction and Saratoga oil fields; outline of approved practise; motor housing, foundation, and installation; transformers; power lines for pumping circuit; lighting circuit; general maintenance; hazards of electrical work.

Electric Equipment

IRON AND STEEL PLANTS. Electrical Developments Committee Report—1930-1931, W. H. Burr. *Iron and Steel Engr.*, vol. 8, no. 6, June 1931, pp. 233-240, 12 figs. During year 1930, 109 main roll drives of 300-hp. or over were installed as compared with total of 201 during previous year; total hp. in main roll drives installed during year was 158,440 as compared with total of 313,000 during previous year; charts showing installed power in various types of mills.

Electric Power

BUILDINGS. Tradition Broken with All-Electric Building, H. T. Crane. *Elec. West*, vol. 66, no. 5, May 1, 1931, pp. 228-232, 17 figs. New headquarters of Southern California Edison Co., Ltd., embody practical application of electricity for all requirements of modern office structure; complete building equipment designed for 100 per cent utilization of electric energy; system and equipment is described.

LUMBER INDUSTRY. Electric Power in the Lumber Industry, A. H. Onstad. *Timberman*, vol. 32, no. 7, May 1931, pp. 36-39 and 42, 9 figs. Highly specialized applications of motor drives evolved for western sawmill and logging service; review of specific application of electric power and equipment.

Elevators

ELECTRIC. Miniature Elevator Enters the Home, C. C. Crispen. *Elec. Jl.*, vol. 28, no. 6, June 1931, p. 379, 4 figs. Latest device for household, called "Inclinator," is traveling car or chain mounted on roller truck running in steel channel alone one side the stairway; when not in use platform and two seats fold up in single movement against metal back, requiring only five in. of space; car designed for vertical ascent is used when stairs are winding.

Engineering

A Half Century of Electrical Engineering, C. F. Scott. *Engrs' Soc. West. Pa.—Proc.*, vol. 47, no. 4, Apr. 1931, pp. 224-225, 16 figs. Historical review of development; conditions 50 years ago; electricity in steel industry; mining and transportation; communication; electricity supplants muscle, skill, and judgment; tools, methods, and men; data regarding electrical development; new industrial revolution; problems created by electricity; chronological review of telephone with special reference to Pittsburgh district.

INFLUENCE ON CIVILIZATION. The Engineer—His Part in Present and Future Civilization, S. S. Arentz. *Professional Engr.*, vol. 16, no. 5, May 1931, pp. 4-6. It is claimed that, just as engineer is leader in bringing about mass production, and invention of labor-saving devices, he can with equal effect bring about solution of problems that must be solved in order to eliminate repetition of such times as world is passing through today. Before Am. Assn. Engrs.

Engineers

What the Engineers Are Doing, A. D. Bailey. *Elec. World*, vol. 97, no. 24, June 13, 1931, pp. 1146-1147. As our industry develops, as our service expands in its present fields and extends into new, technical details involved and prob-

lems to be met are bound to increase rather than to diminish both in number and importance; engineers will be needed who not only possess high technical qualifications but who are blessed with ambition and imagination as well; men who are trained to analyze and to think straight. Before Nat. Elec. Light Assn. Annual Convention.

Gages

PIEZOELECTRIC. Piezo-Electric Gage and Amplifier, R. A. Webster. *Franklin Inst.—Jl.*, vol. 211, no. 5, May 1931, pp. 607-616, 7 figs. Pressure gage was designed and built using cartridge of pure bakelite; within this was placed pile of 21 quartz crystals, each 0.69 in. sq. by 0.053 in. thick, they being separated by platinum electrodes; screwed brass ends held them in cartridge which was then sealed with beeswax; 3/8-in. piston bore upon this pile; this gage has given very good service and although few of crystals cracked, no loss in sensitivity has been noticed.

Galvanometers

SUSPENSIONS. Note on Julius Suspensions, M. J. Brevoort. *U. S. Bur. Mines—Report of Investigations*, no. R. I. 3086, Mar. 1931, 2 pp., 1 fig. on supp. plate; see also *Instruments*, vol. 4, no. 5, May 1931, pp. 277-278, 1 fig. Research work in Bureau of Mines cryogenic laboratory requires use of high-sensitivity galvanometers of d'Arsonval type in building that is subject to unusually severe vibrations; modified form of galvanometer suspension described by Julius in Annalen Physikalische Chemie of 1895, has damped vibrations successfully.

Generators

D-C. DESIGN. Relation of Coil and Brush Current in a Direct-Current Machine, R. M. Baker. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 383-386, 3 figs. General expression for current and voltage relations in armature coil; magnitude of circulating current in brushes; effect of over-compensation.

WATERWHEEL. A Comparison of Exciters for Waterwheel Generators, T. J. Woth. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 343-344, 3 figs. There are three principal types of exciters for waterwheel generators; direct-connected, separate turbine driven, and motor-generator set; advantages and disadvantages of each have important bearing on design and cost of complete station.

Heating

HEAT STORAGE. Solid-Core Thermal-Storage Heating Units, L. G. A. Sims and K. R. Sturley. *Engineering*, vol. 131, nos. 3407 and 3410, May 1, 1931, pp. 561-564, and May 22, pp. 664-665, 23 figs. Systems heretofore employed in Great Britain are not convenient in cases where single small rooms and single offices have to be heated; for this purpose, unit type of heater is needed, having loading of few kilowatts only, capable of being installed without alteration to structure of building; results of experiments made in Electrical Engineering Department of University of Birmingham on one of best Continental heaters, and development of greatly improved design.

Hoover Dam

Hoover Dam Will Provide 1,000,000 Hp. *Power Plant Eng.*, vol. 35, no. 12, June 15, 1931, pp. 643-645, 2 figs. Great project of Bureau of Reclamation includes dam 730 ft. high at Black Canyon on Colorado River, power plant, diversion and water control works and other features; general plan and section of Hoover dam, showing cofferdams and diversion tunnels.

Hydroelectric

POWER DEVELOPMENTS. A Power Development on the Columbia River, T. B. Parker. *Stone and Webster Jl.*, vol. 48, no. 5, May 1931, pp. 331-345, 7 figs. Rock Island hydroelectric development on Columbia River 12 mi. downstream from City of Wenatchee, Washington is built for Puget Sound Power and Light Co.; development will have several novel features, and will be first large low head development in Northwest it will be designed for ultimate capacity of 150,000 kw. under normal head of 48 ft.; initial installation will be 60,000 kw.

Power Plants

PUMPED STORAGE. Pumped Storage for Regeneration, L. F. Harza. *Power Plant Eng.*, vol. 35, no. 2, June 1, 1931, pp. 597-601, 4 figs. Methods of storing energy on large commercial scale; European practise of pumped storage power; pump-fed storage plants in Germany; design and operation features of several large plants in Germany; list of advantages and disadvantages of hydraulic storage; efficiency of conversion; economical capital expenditure limit.

REMOTE CONTROL. Automatic and Remotely Controlled Hydro-Power Plant. *AEG Progress*, vol. 7, no. 5-6, May-June 1931, pp. 99-106, 8 figs. Review of automatic and remotely controlled plant on basis of experience accumulated by AEG is construction of numerous automatic hydro-power stations for output totalling well over 100,000 kw.; important factors requiring study when planning electrical section of small and medium sized stations.

Insulating Materials

RUBBER. Rubber for Electrical Uses, A. R. Dunton and A. W. Muir. *Elecn.*, vol. 106, no. 2762, May 8, 1931, pp. 679-681, 1 fig. Vulcanization; tapes, flexible wire and cable insulation; ebonite and vulcanite; molding difficulties.

SPECIFICATIONS. Report of Committee D-9 on Electrical Insulating Materials. *Am. Soc. Testing Mills—Advance Paper*, no. 74, for mtg. June 22-26, 1931, 25 pp., 3 figs. Recommendations affecting standards and tentative standards; subcommittee I on insulating varnishes; subcommittee II on molded insulating materials; subcommittee on sheet insulation; subcommittee IV on liquid insulation; subcommittee VII on electrical tests; section A, of subcommittee IV, on neutralization methods for electrical insulating oils; electrometric methods for determination of neutralization number of mineral insulating oils.

Lamps

INCANDESCENT. Report of the Lamp Committee—June, 1931. *Nat. Elec. Light Assn.—Pub.*, no. 136, June 1931, 8 pp., 10 figs. Statistical data, covering incandescent-lamp industry; lamp developments that have taken place during year; importance of applying proper voltage lamp to obtain most economical and best results.

TUNGSTEN. Production of Color from Tungsten Lamps, M. Luckiesh. *Elec. World*, vol. 97, no. 14, Apr. 4, 1931, p. 645. Amount of light emitted in each of spectral regions by various sizes of tungsten lamps is listed.

Lighting

The Art of Illumination—II, J. W. T. Walsh. *Illum. Engr.*, vol. 24, May 1931, pp. 111-114. Specimen installations in many different classes of lighting problems ordinarily met with in practise.

AUTOMATIC CONTROL. The Automatic Control of Lighting Installations, E. H. Vedder and S. G. Hibben. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 5, May 1931, pp. 517-523 and (discussion) 523-525, 8 figs. on supp. plates. Changing customs and requirements that impose more difficult demands upon manual control of many lighting circuits, have brought about logical development of automatic light-sensitive switching devices; photoelectric tube constitutes foundation of automatic control units, which, with its accessories and typical assembly, is described briefly; several actual and some suggested applications are mentioned, that seem destined to widen service to which artificial light will soon be put.

BUILDINGS. Electric Light on Metal in Architecture, E. Clute. *Elec. Specifications*, vol. 3, no. 5, May 1931, pp. 14-22, 11 figs. First of series of articles on materials in combination with electricity; examples showing effects of amber light on nickel grill and aluminum leaf of recessed light source, walls of black marble of light on nickel-chrome steel of reflector casings, crestings of store fronts and doors, red marble walls with buff veining on corrugated white metal backing of recess, grille of carved satinwood painted in polychrome; lighting and floodlighting features of various outstanding buildings of recent date are illustrated.

Lightning Arresters

TESTING. Cathode-Ray Oscillograph Tests Arrester Production, O. A. Ackermann. *Elec. World*, vol. 97, no. 19, May 9, 1931, p. 866, 2 figs. Criterion for acceptability of unit blocks which make up autovalve lightning arrester is volt-ampere curve; Westinghouse Electric & Manufacturing Company is using cathode-ray oscillograph in connection with surge generator for purpose of testing; oscillograph used for this purpose is of glass tube type, developed in Westinghouse Company originally for television purposes.

Lightning Protection

HIGH TENSION LINES. 220-Kv. Arrester on Long Line, G. C. Dill. *Elec. World*, vol. 97, no. 18, May 2, 1931, pp. 804-806, 6 figs. Hydro-electric power commission of Ontario recently has placed on 220-kv. side of Leaside substation near Toronto unique and notable installation of four 3-phase SV autovalve lightning arresters; protection problem was difficult; it would require 22 units to handle these dynamic over-voltage conditions of 266 kv. line to ground; arresters that were decided upon met these two requirements by new and very unique design.

Loud Speakers

A Loud Speaker Good to Twelve Thousand Cycles, L. G. Bostwick. *Bell Laboratories Rec.*, vol. 9, no. 9, May 1931, pp. 433-436, 5 figs. In loud speaker under discussion, factors that usually cause high frequencies to be suppressed have been taken into consideration; diaphragm is made of .002-in. duralumin and is little over one inch in diameter; moving coil of aluminum ribbon wound edgewise is attached to diaphragm at periphery of embossed section and vibrates in very strong magnetic field in usual way; diaphragm and moving coil weigh together but 160 mg.

MOVING COIL. The Moving Coil Loud Speaker, H. M. Clarke. *Experimental Wireless*, vol. 8, no. 93, June 1931, pp. 304-306, 2 figs. If no allowance is made for possible change in electrical constants, dynamic impedance attributed to moving system and measured by difference of input resistance and reactance of system when in motion, from those of system at rest, may be considerably in error; with view to observing possible existence of such changes, author has carried out experiments.

Magnetic Hardening

METALS. Hardening Metals by Rotating Magnetic Fields, E. G. Herbert. *Metallurgia*, vol. 3, no. 18, Apr. 1931, pp. 219-221, 8 figs. Author describes his discovery of remarkable changes produced in metals by action of rotating magnetic field; hardening of alloy steels; application to non-ferrous metals, such as duralumin, rod brass and brass sheet.

Hardening Metals by Rotating Magnetic Fields, E. G. Herbert. *Metallurgia*, vol. 4, no. 19, May 1931, pp. 9-13, 17 figs. New developed magnetic phenomena is applicable to hardening of tools of any type or design; treatment occupies not more than two minutes at temperatures not exceeding 200 deg. cent.; data on experiment with alloy steels, duralumin and brass; graphs indicating results and comparison with other hardening processes. Bibliography.

Magnetic Testing

IRON AND STEEL. Relation Between Magnetic Properties, Impact Strength and Hardness, H. Styri. *Am. Soc. Testing Matls.—Advance Paper*, no. 33, for mtg. June 22-26, 1931, 12 pp., 4 figs. Results of investigation of subcommittee of Society's Committee A-8 on magnetic analysis, formed to investigate relationship between magnetic testing and impact strength and hardness; results are summarized in graphical form.

Magnets

DESIGN. Permanent Magnets for Electronic Instruments, W. H. Hoppe. *Electronics*, vol. 2, no. 5, May 1931, pp. 636-638, 3 figs. Permanent magnets represent inconspicuous but important part of many electronic devices, *e. g.*, measuring instruments, sound pickups and other well-known apparatus; principles of design of such magnets are described.

Measurements

Accurate Measurement of Small Electric Charges by a Null Method, L. S. Taylor. *U. S. Bur. Standards—Jl. Research*, vol. 6, no. 5, May 1931, pp. 807-818, 5 figs. partly on supp. plate. New method for calibrating null system in such manner that capacity of leads does not enter and which, therefore, permits reduction in calibration error to one-tenth; when system is once calibrated in manner described, any unknown capacity whatever may be added to leads without affecting measurement of desired quantities; applications to measurements of current, charge and capacity.

Measuring Instruments

Electrical Maintenance Instruments, A. I. Greenwood. *Power Plant Eng.*, vol. 35, no. 12, June 15, 1931, pp. 669-670, 4 figs. Grounds and insulation tests with discussion of methods and instruments used in making them; accurate resistance measurement.

Metering

THREE-PHASE. The Metering of Three-Phase Supplies, O. Howarth. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 413, May 1931, pp. 637-646, 3 figs. Discussion by A. E. Moore, A. E. Jepson, A. M. Strickland and others, of paper previously indexed from issue of Mar. 1931; also reply by author.

Meters

Meter Committee Reports. *Elec. West.*, vol. 66, no. 6, May 15, 1931, pp. 385-401, 25 figs. Reports of Pacific Coast Electric Association on meter obsolescence; reactive kva. metering; special tests and investigations; determining ground resistance; calibration of high voltage potential transformers using standard of different voltage rating; oscillographic measurement of time intervals; tests on various forms of relays; operating problems of meter department.

Motors

CAPACITOR. The Design of Capacitor Motors for Best Starting Performance, B. F. Bailey. *Univ. Mich.—Dept. Eng. Research—Eng. Research Bul.*, no. 19, Apr. 1931, 23 pp., 12 figs. Having been called upon to design large number of capacitor motors, writer has endeavored to simplify fundamental theory and methods of making necessary computations; portion of theory which relates to locked or starting torque of capacitor motors is presented in its simplified form.

SQUIRREL CAGE. Full-Voltage Starting Simplifies A-C. Motor Applications, E. W. Henderson. *Power*, vol. 73, no. 20, May 19, 1931, pp. 770-772, 7 figs. Squirrel-cage motors have been developed that can be started by connecting them directly to line and yet maintain inrush current within N.E.L.A. recommendations; these motors have full-speed characteristics practically as good as those started on reduced voltage, and employ much simpler and less expensive starting equipment.

THREE-PHASE. Three-Phase Commutator Motors for Outputs Up to 16-5 kw., M. Mogensen. *Brown Boveri Rev.*, vol. 18, no. 6, June 1931, pp. 187-195, 22 figs. For many years Brown, Boveri & Co., have made complete range of three-phase commutator motors intended for textile industry for variable speed individual drive of ring spinning and twisting frames; they have also found many other fields of application; range of motors has undergone repeated improvements; new series of three-phase commutator motors thus formed is described in greater detail.

Networks

CURRENT CONVERSION. Planning Successive Steps in Network Cut-over, C. W. Evans. *Elec. World*, vol. 97, no. 20, May 16, 1931, p. 909, 1 fig. 13-kv. feeders formed nucleus from which small sections were gradually enlarged until two or three sections could meet and merge into one; this gradual expanding of smaller section was greatly simplified by secondary junction boxes, which were already installed in most manholes; since these boxes are provided with links it was simple matter to sectionalize new system from old.

DESIGN. A Non-Mathematical Analysis of the Measurement of Symmetrical Components, A. P. Hayward. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 351-357, 17 figs. Simple, non-mathematical analysis of physical basis of measurement. Bibliography.

OVERVOLTAGES. Over-Voltage Problems, A. H. Von Altmann. *Engineer*, vol. 151, no. 3934, June 5, 1931, pp. 634-635, 5 figs. Attempt is made to show that most dangerous over-voltages are caused by direct lightning strokes; proposals submitted in recent years for protecting overhead lines and plant; apparatus used for combating overvoltage phenomena.

UNDERGROUND. Underground Systems Reference Book. National Electric Light Association. N. Y., The Association, 1931, 377 pp., illus., diagrs., charts, tables, $4.00. Number of leading American authorities have assisted in editing this description of accepted practise in design, construction and operation of underground systems of electric distribution; cables and their insulation, conduit and manhole design and construction, cable installation, splices and terminals, cable operation, miscellaneous equipment and safety practises are discussed in detail. Bibliography of over 4,000 references. Eng. Soc. Lib., N. Y.

Ohmmeters

VACUUM TUBE. A Thermionic Megger with Linear Scale, O. Stuhlman. *Franklin Inst.—Jl.*, vol. 211, no. 5, May 1931, pp. 617-625, 5 figs. Writer proposes to use any tube with dynatron characteristics; if change in slope of given phase of characteristic can be shown to change in proportion to change in external resistance it should follow that for predetermined current, voltmeter recording potential across filament and plate can then be calibrated to read resistances directly; voltmeter's linear scale is then direct reading megohmmeter.

Photoelectric Cells

Concerning the Grid-Leak of a Grid-Photoelectric Tube, T. Asada and K. Hagita. *Inst. Elec. Engrs., Japan—Jl.*, vol. 51, no. 2, Feb. 1931, pp. 99-102, 5 figs. In previous paper on "Supersensitive Photoelectric Tube," it is reported that so-called grid-photoelectric tube or grid-tube is much more sensitive than other ordinary photoelectric tubes, and it has no phenomena of time-lag and fatigue; in this paper it is reported that this connection of grid with filament through a high resistance, which is similar to grid-leak of a triode, is very important for grid-tube. (In Japanese with English abstract on pp. 17-19.)

INDUSTRIAL APPLICATIONS. Power Control by Means of Phototubes, W. R. G. Baker, A. S. Fitzgerald and C. F. Whitney. *Electronics*, vol. 2, no. 5, May 1931, pp. 632-633, 6 figs. Use of phototube in various fields; wiring diagrams of light-operated relay circuit, system controlling power by light beams, Selenium-Thyratron system for illuminating control and smoke-density recorder circuit; color comparator by which phototube matches roast of coffee.

Power Factor

IMPROVEMENT. Alignment Charts for Power Factor Improvement, W. A. Barclay. *Elec. Engr. Australia and New Zealand*, vol. 8, no. 1, Apr. 15, 1931, pp. 19-22, 3 figs. Use of two charts, which author has drawn up, in determining size of condenser required for correcting power factor of circuit by specified amount; charts bring calculation of corrective kva. to simplest possible terms.

Power-Factor Correction Cuts Costs, J. F. Wulfetange, Jr. *Elec. World*, vol. 97, no. 14, Apr. 1931, pp. 628-631, 3 figs. Industrial plants in Pittsburgh, Pa., are encouraged to correct power factor by new "W" rate of Duquesne Light Co., offering low energy rates for high power factor demands; capacitors have proved economical, effective means of raising kw./kva. ratio either in supplementing or in substitution for synchronous machines.

Protection

HIGH TENSION LINES. The Petersen Coil for Power System Arc Suppression, W. F. Mainguy. *Elec. News*, vol. 40, no. 10, May 15, 1931, pp. 47-49 and 58, 3 figs. Short review of European development; notes on principle of coil which is applicable only to ungrounded system; solidly grounded neutral system; isolated neutral system; size of coil; connection of coil.

Radio

AMPLIFIERS—COUPLING. Theory and Operation of Tuned Radio-Frequency Coupling Systems, H. A. Wheeler and W. A. MacDonald. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 5, May 1931, pp. 738-803 and (discussion) pp. 804-805. Gain of amplifier can be held uniform or made to vary with frequency in any desired manner consistent with amplifying ability of tube and tuned secondary circuit, and without appreciable loss of selectivity; large variety of these improved coupling circuits is shown and classified in terms of fixed and varying components of equivalent mutual inductance; number of these coupling systems from commercial receivers are described in terms of coil structure, electrical constants, and performance.

BROADCASTING. Radio Network Broadcasting, R. H. Owen and W. G. Rubel. *Engrs. Bul.*, vol. 15, no. 4, Apr. 1931, pp. 5, 28-29 and 35, 2 figs. Discussion is intended to give more or less comprehensive idea of what is involved in connection with network broadcasting; present day program transmission circuits in United States are on "voice frequency basis"; in transmitting programs over wire network, it is important that volume range be held within proper limits; it is one of obligations of one who handles program pick-up to hold his range of volume between proper limits.

BROADCASTING, LONG WAVE. Low-Frequency High Power Broadcasting as Applied to National Coverage in the United States, W. H. Wenstrom. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 6, June 1931, pp. 971-983, 3 figs. With P. P. Eckersley's general theory derived from north European practise as starting point, possibilities of broadcasting in United States on frequencies around 200 kc. are examined from viewpoint of national coverage; it is shown that under specified conditions Eckersley's curves can be applied approximately to American terrain.

DIRECTION FINDING. The Practical Correction of a Wireless Direction-finder for Deviations due to the Metalwork of a Ship, C. E. Horton. *Experimental Wireless*, vol. 8, no. 91, Apr. 1931, pp. 195-198, 11 figs. Brief review of errors that may occur was due to immediate surroundings of direction-finder as in a ship. Before Inst. Elec. Engrs.

TELEPHONE, SHORT WAVE. Single Side Band Short-Wave Wireless Telephony. *Engineer*, vol. 51, no. 3932, May 22, 1931, pp. 570-571, 4 figs. New system of radio telephony in which single side band is applied to short-wave transmission, was demonstrated at experimental radio station of Matérial Téléphonique at Trappes, near Paris; results represent reward of long search for means of applying single side-band method, with its well-known advantages, to short-wave radio transmission, problem that has hitherto presented almost insurmountable difficulties.

ULTRA-SHORT WAVE. Communication on the quasi-optical frequencies, E. Karplus. *Electronics*, vol. 2, no. 6, June 1931, pp. 666-667, 4 figs. Problems in communication waves in Barkhausen and Kurz range; various laboratory equipment; transmitter and receiver by I. T. &. T. experiments across English Channel on wavelength of 18 cm.; notes on problems of reception; ultra-high frequency wavemeters.

Railroads

AUTOMATIC CONTROL. Automatic Operation at the Cleveland Union Terminals, F. E. Jaquay. *Gen. Elec. Rev.*, vol. 34, no. 6, June 1931, pp. 350-356, 9 figs. Automatic and supervisory control which has now been in successful operation for nearly a year on Cleveland Union Terminal Electrification is very important part of this project which, at time of placing in service, was first application of 3,000 volts d-c. for heavy electric traction in east; electrified zone includes total of approximately 17 mi. of route and some 60 mi. of single track; importance of 100 per cent reliability in operation of this system handling between 100 and 150 trains daily is stressed.

REGENERATIVE CONTROL. Railway Regenerative Braking, J. A. Colaco. *Elec. Rev.*, vol. 108, no 2793, June 5, 1931, pp. 945-946, 4 figs. General improvement in operating conditions, more than saving in energy consumption, has justified adoption of system on Great Indian Peninsula railway.

SIGNALS AND SIGNALING. The Effect of Signalling on Track Capacity, C. R. Byrom. *Inst. Transport—Jl.*, vol. 12, no. 7, May 1931, pp. 326-340 and (discussion) 340-347, 8 figs. Historical review of signal developments; automatic signals; route indicators; manual versus automatic signaling.

SIGNALS AND SIGNALING, AUTOMATIC. N. Y. C. Re-Signals Tracks Entering Grand Central Terminal. *Ry. Age*, vol. 90, no. 18, May 2, 1931, pp. 856-858, 3 figs. Train operation in either direction on each of four tracks facilitates traffic and increases track capacity; track and signal plan of territory between Grand Central Terminal and Mott Haven; outline of new signaling system.

TRAIN CONTROL—CAB SIGNALING. Taking the Flicker Out of Cab Signal Lights. *Ry. Elec. Engr.*, vol. 22, no. 5, May 1931, pp. 119-121, 5 figs. Both track and locomotive irregularities may result in fluctuating indications; close attention to relay pick-up values and track circuit conditions will remedy trouble causes of fluctuating indications; typical 60-cycle loop system of continuous control, double track; typical coder continuous track circuits, track d-c. control and a-c. signal circuit.

UNITED STATES. 1930 a Difficult Year for the Electric Railways, E. J. Murphy. *Aera*, vol. 22, no. 5, May 1931, pp. 260-266. Sharp reduction in traffic and revenues produced by business depression severely taxed resources of industry in 1930; only by again stepping up operating efficiency and, in addition, closely adjusting service to reduced volume of business were they able to meet all obligations; tabular review of combined operations of electric railroad companies for 1929 and 1930.

Rate Making

POWER INDUSTRY. More Equitable Rate Forms an Industry Obligation, T. O. Kennedy. *Elec. World*, vol. 97, no. 22, May 30, 1931, p. 1008. With rate schedules based on rate per kw-hr. it is only natural that our customers should look upon electricity as commodity, whereas it can equitably be sold and charged for only as service; it is obligation of our commercial departments to promote adoption of more equitable type of rate.

Reactive Power

METERING. Reactive Kva. Metering—VIII, E. O. Goodale. *Elec. West.*, vol. 66, no. 5, May 1, 1931, pp. 233-234, 3 figs. Three-element meters give accurate registration of reactive Kva. on four-wire circuits if voltages are balanced.

Rectifiers

MERCURY-ARC. Mercury-Arc Power Rectifiers—Their Construction and Operation, W. E. Gutzwiller. *Power*, vol. 73, no. 24, June 16, 1931, pp. 950-953, 7 figs. Mercury-arc power rectifiers have in few years been developed to where they are now keen competitor of rotary converters and motor-generator sets; built in size up to 6,000 kw., for voltages up to 3,000 and to supply all kinds of d-c. loads; cross-section through large mercury-arc power rectifier; diagram of connections for 6-phase manually operated rectifier unit.

Mercury Arc Rectifier for Electric Railroads, L. G. Raschkovsky. *Electritchestvo*, no. 9, May 1931, pp. 466-469, 5 figs. Characteristic properties; advantages over synchronous con verters; application on electric locomotives.

3,000-Volt Traction Rectifiers. *Engineer*, vol. 151, no. 3933, May 29, 1931, pp. 606-607, 2 figs. In electrification program by Delaware, Lackawanna and Western Railway, for converting 60-cycle a-c. into 3,000-volt d-c., mercury-arc rectifiers were chosen, in preference to motor-generators, because of their relatively low first cost, high efficiency, and ability to carry heavy overloads without injury; other advantages are small floor space and simple foundations. From article, by E. L. Moreland, previously indexed from Gen. Elec. Rev., Mar. 1931, under classification of Railroad Electrification—United States.

Relays

HIGH TENSION LINES. Theory and Application of Relay Systems—Ground-Fault Protection of Loop Systems—I, P. H. Robinson and I. T. Monseth. *Elec., Jl.*, vol. 28, no. 6, June 1931, pp. 375-378, 5 figs. For simple loop system consisting of one generating station and having transformer neutrals grounded at only this one point, impedance or directional-overcurrent ground relays are most frequently applied; more complicated systems require use of other types of relays; loop system with one grounded neutral point discussed.

TESTING. Some New Information Regarding the Installation and Testing of Brown Boveri Distance Relays, J. Stoecklin. *Brown Boveri Rev.*, vol. 18, no. 5, May 1931, pp. 175-179, 7 figs. Brown Boveri distance relay protection has been adopted to great extent in short time, and valuable suggestions have more than once been made by users with view to simplifying installation of relays, and also to render possible carrying out of periodical tests.

Remote Metering

The Midworth Distant Repeater. *Elec. Engr. Australia and New Zealand*, vol. 8, no. 1, Apr. 15, 1931, pp. 22-24, 4 figs. Instrument for providing remote indication of various values, and of its application for measuring bulk electricity supplied to Melbourne city council.

Substations

Laconia Avenue Distribution Station of the Bronx Gas and Electric Company, S. Wilder. *Gen. Elec. Rev.*, vol. 34, no. 6, June 1931, pp. 374-376, 5 figs. Purpose of article is not to present details of design or operation of automatic supervisory equipment but rather to describe briefly typical substation, furnished with such equipment, and to give some operating data in regard to installation; electrical energy purchased from United Electric Light and Power Co. is supplied over 13,200-volt feeders from this company's Sherman Creek and Hell Gate stations.

Switchboards

MINIATURE. Miniature Switchboards: A New Type of Control Switchboard for Electric Power Stations and Substations, P. Sporn. *Gen. Elec. Rev.*, vol. 34, no. 6, June 1931, pp. 336-342, 10 figs. Purpose and development of miniature switchboard; description of board and equipment; installations; advantages; experience in service.

Switchgear

Substation Switchgear, F. C. Orchard. *Elec. Times*, vol. 79, no. 2066, May 28, 1931, pp. 963-964, 3 figs. Main principles underlying design of substation are that apparatus shall be of sound design and construction so that breakdown is infrequent and apparatus shall be arranged so that it can operate under conditions for which it is designed; design of switchgear, which is most important apparatus in substation, is very largely effected by characteristics of high voltage system and not entirely by service to be given by substation.

AUTOMATIC. Automatic Switching Equipment in Industry, F. P. Brightman. *Gen. Elec. Rev.*, vol. 34, no. 5, May 1931, pp. 284-287, 4 figs. Applications in mines, steel mills, paper mills, and glass industry preferred-emergency service; advantages derived from use of automatic equipment are elimination of full time operator, of difficulties attributable to inefficient manual operation; reduction in feeder losses; reduction in number and duration of outage.

METAL CLAD. Metal Clad Switchgear. *Elec. West*, vol. 66, no. 6, May 15, 1931, pp. 334-339, 9 figs. Report on types used and typical installations by Electrical Apparatus Committee of Pacific Coast Electric Association.

Telephone

Recent Development in Telephony, E. H. Colpitts. *Military Engr.*, vol. 23, no. 129, May-June 1931, pp. 247-254, 9 figs. Growth and improvements in toll circuits; toll cable improvements; gas pressure testing of cable; open-wire circuits and voice-frequency use; open-wire carrier circuits; program translation; Cuba-Key West cables; radio telephone; improvements in wire insulation; private branch exchange telephone system; new order receiving equipment.

CARRIER CURRENT. Current Carrier Telephony, A. C. Timmis. *Instn. Post Office Elec. Engrs.—Paper*, no. 131, for mtg. Feb. 11, 1930, 47 pp., 23 figs. Carrier telephony over transmission lines with particular reference to lines used primarily for ordinary telephone circuits; general principles; transmission; present state of art in various countries; future development.

INDUCTIVE INTERFERENCE. Foreign Systems Co-ordination Committee Reports. *Elec. West*, vol. 6, May 15, 1931, pp. 342-360, 23 figs. Report of Pacific Coast Electric Association on inductive coordination of Hoover Dam transmission line; Serjdetour telephone protector; power company telephone line protection; tests on soldered sleeve joints in telephone line construction; sleeve rolling tool and single tube sleeve; remote alarms over telephone circuits; radio coordination; common neutral.

Inductive Coordination Laboratory, E. L. Fisher. *Bell Laboratories Rec.*, vol. 9, no. 10, June 1931, pp. 481-485, 7 figs. To study under fully controlled conditions some of various effects of voltages induced in telephone lines by disturbances in neighboring power circuits, assembly of equipment has been made in laboratories.

LONG DISTANCE—TOLL SYSTEM. Standard Switching Plan for Telephone Toll Service, H. S. Osborne. *Commercial Standards Monthly*, vol. 7, no. 11, May 1931, pp. 351-352. Efficiency increased through improved coordination in planning, designing, and arrangement of toll plant; general plant described as comprehensive countrywide network of toll circuit facilities connecting important switching offices over which practically all traffic, not handled by direct circuits, will be routed.

Teletypes

The Engineering and Traffic Aspects of Teleprinter Development, A. P. Ogilvie and F. W. Dopson. *Telegraph and Telephone Jl.*, vol. 17, no. 194, May 1931, pp. 176-178, 7 figs. Type of apparatus that is being installed and general effect of its adoption on telegraph service as whole. Before Telephone and Telegraph Soc., Lond.

Testing

HIGH TENSION LINES. Fault Currents on 110-kv. Line Checked by Service Tests, L. M. Robertson. *Elec. West*, vol. 66, no. 5, May 1, 1931, p. 235, 2 figs. Measuring false currents, potential gradients, and telephone interference on its new 110-kv. wood-pole, H-frame transmission line of Public Service Co. of Colorado, are described; two types of structures were tested, one, with all insular and crossarm hardware bonded and grounded and connected to overhead wire, other type made full use of wood for insulation.

Transients

HIGH TENSION LINES. Automatic Recording of System Disturbances, J. T. Johnson, Jr. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 335-339, 12 figs. With Osiso, records of transients on system of Alabama Power Co. have been recorded automatically which showed clearly and sharply all but first cycle; Osiso was mounted on portable wooden base containing all accessories necessary for automatic operation and then used for taking hundreds of records in score of different studies.

Transmission Lines

DESIGN. Transmission Line Built Across 53 Others, F. Curtis, *Elec. West*, vol. 66, no. 7, June 1, 1931, pp. 616-617, 5 figs. Design of 62-mi. 110-kv. interconnection over 53 power lines, some of 66-kv. potential, 44 telephone lines, two trolley lines, 17 railroads, two state highways, 50-ft. water tower and seven houses between San Bernardino substation of Southern Sierras Power Co. and Los Angeles Gas and Elec. Corp., Seal Beach steam electric plant.

Welding

ARC. Research Covering Alternating Current Arc Welding, G. A. Hughes and R. C. McBridge. *Iron and Steel Engr.*, vol. 8, no. 6, June 1931, pp. 241-246, 12 figs. Possibilities of a-c. arc welding, *i. e.*: chemical analysis of metal deposited, rate of deposit, ductility, tensile strength, penetration, non-ferrous metal, electrical characteristics, and bare and coated electrodes, are investigated; test results are given.

Study of Variables the Basis of Progress in Fusion Welding, C. A. Adams. *Power*, vol. 73, no. 21, May 26, 1931, pp. 813-814, 1 fig. Research has disclosed importance of understanding effects of metallurgical, chemical, mechanical and electrical variables on art of fusion welding, and has made possible its application to power plant equipment.

CAST IRON. Cast Iron To-day, A. B. Everest. *Welding Jl.*, vol. 28, nos. 330 and 331, Mar. 1931, pp. 80-83 and Apr., pp. 102-106 and (discussion) 106-109, 15 figs. Paper is presented in belief that welding engineers to-day are becoming increasingly interested in application of their art to all engineering structures, among them castings, and therefore are interested in structure and nature of commonest metal used for cast structures. Before Instn. Welding Engrs.

ELECTRODES. A New Improved Electrode for Arc Welding Stainless Steel. *Welding Jl.*, vol. 28, no. 331, Apr. 1931, pp. 118 and 120, 5 figs. New, improved electrode for arc welding of stainless steel has been recently developed by Lincoln Research Laboratories and is now being manufactured by Lincoln Electric Co., Cleveland, Ohio.

IRON AND STEEL PLANTS. Maintenance Welding in Steel Plant is Essential, E. L. Quinn. *Welding*, vol. 2, no. 5, May 1931, pp. 320-324 and 331. Application of thermit, electric arc and oxyacetylene welding to various types of repair work; procedure in welding of steel, cast iron, bronze welding of cast iron; surface hardening alloys; qualification of operators.

PIPE LINES. Progress in Arc Welded Construction of Oil Pipe Lines, J. F. Lincoln. *Oil Weekly*, vol. 61, no. 8, May 8, 1931, pp. 67-68, 72 and 76, 10 figs. Review of development in 1930; physical properties of welded joints; resistance to corrosion; ductility; welding procedure; tacking; rolling welds; tie-in welds; speed of welding; equipment; oil-carrying pipe lines welded by new shielded arc process; 1010 mi. of pipe line containing 106,885 joints fabricated or now under construction.

PRESSURE VESSELS. Electric Welding Applications to Steam Pressure Vessels. *Power Plant Eng.*, vol. 35, no. 12, June 15, 1931, pp. 667, 4 figs. Electric welding of steam piping and directly fired steam drums has now passed experimental stage of development and during past year and half number of noteworthy applications have been made in power plant field; review of outstanding applications.

UNITED STATES. Some Achievements in Arc Welding in the United States During 1930, L. D. Meeker. *Sheet Metal Industries*, vol. 5, no. 1, May 1931, pp. 49-50. Welded steel structures built in 1930; automatic welding machines; atomic-hydrogen welding.

Welds

TESTING. Testing Butt Welds by Magnetic Methods, T. R. Watts. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 389-391, 6 figs. In magnetic testing of butt welds in steel, faults are detected because of their higher reluctance; means of detecting regions of abnormally high reluctance, that is, faults, may be classified as "magnetrographic inspection" and measurements of leakage flux by means of weld-test meters.

Industrial Notes

American Insulators for Egypt.—The Ohio Brass Company, of Mansfield, Ohio has received a third order for insulators and transmission line hardware to be used in connection with the extensive electrification projects of the Egyptian government, now nearing completion in the Nile Valley. This most recent order for suspension insulators and hardware fittings amounts to approximately $79,000 and brings the total volume of orders received during the past twelve months for this project to $250,000.

General Electric Reports Decreased Sales.—Orders received by the General Electric Company for the first six months of 1931 amounted to $141,428,978, compared with $190,313,758 for the corresponding period last year, Gerard Swope, president, announced today. Sales billed for the six months of 1931 amounted to $141,180,091.13, compared with $197,229,346.82 for the corresponding period last year.

The National Electric Products Corporation, Pittsburgh, announces the opening of its own branch at 400 Potrero Street, San Francisco, taking over the stocks and active operations for the company on the Pacific Coast. Garnett Young & Company, who have for many years represented the National Company, resigned April 8 to take effect July 15.

The Square D Company of Texas, a subsidiary of the Square D Company, Detroit, recently opened its new factory at 3111 Polk Avenue, Houston, to service the southwest's electric equipment requirements. The Square D Company of Texas was organized in 1928 to serve the southwest with special switchboards, lighting and power panelboards, special motor control and standard Diamond E material. Branches are operated in Little Rock, Ark., Dallas and Houston, Texas.

A New Safety Switch.—The Rowan Controller Company, Baltimore, manufacturer of completely oil immersed control equipment, has recently introduced a combination safety switch and magnetic contactor for use with small alternating-current motors. The equipment can be furnished up to and including 5 horsepower, 220, 440 or 550 volts. The unit is compactly built so that it occupies a minimum of wall space, and the fact that it is completely oil-immersed makes it vapor-proof, weather-proof, and dust-tight.

New Motor Starter.—The Electric Controller & Manufacturing Company, Cleveland, Ohio, announces a new line of explosion-proof motor starters, type ZS, across-the-line, providing for full voltage starting of squirrel cage motors. These starters may also be used with an automatic field switching panel for synchronous motors and for the control of the primary of slip-ring motors. An oil tank which contains the main line contactor, is equipped with a sight oil gage to indicate the oil level inside the tank. Bolted to the rear of the tank is an explosion-proof case which contains the overload relay panel and which also serves as a conduit connection box. Maintenance is greatly reduced, because the operating mechanism is always well protected against moisture and corrosion.

Recent Westinghouse Orders.—The Westinghouse Electric & Manufacturing Company announces recent orders that include a 25-kva. synchronous condenser and automatic control switching equipment for the Puget Sound Power & Light Company. An order from the Management & Engineering Corporation, of Chicago, covers eight 2,500-kva. and seven 1,667-kva. transformers to be used to increase the capacity of the Indianapolis Power & Light Company 33,000-volt load. The Commonwealth Edison Company has ordered the first alternating-current calculating board for commercial use at a cost of approximately $50,000. The board will be located at Chicago and will be used to determine system operating conditions under various loads and schemes of operation. Only two other alternating-current calculating boards are in use,— one is at the Westinghouse plant in East Pittsburgh and the other at the Massachusetts Institute of Technology, Cambridge, Mass.

Burgess Radiovisor Bridge.—The Radiovisor Division of the Burgess Battery Company, 295 Madison Ave., New York, has announced a new light-sensitive cell representing the original development of British scientists, followed by the ingenious applications by German technicians, and finally the adaptation of the cell and its circuit to American practise. The new cell or bridge consists of a tall glass tube with a three-pronged base similar in general appearance to an ordinary radio tube. Inside the bulb and supported by two heavy lead-in wires is a plate of glass on the front side of which are two interlocking comb-like electrodes of gold leaf fused in place. Covering these electrodes is a thin layer of light-sensitive enamel derived from selenium. Extreme ruggedness is claimed for the new light-sensitive device, including the capability of handling relatively heavy current. Each bridge has a maximum rating of 0.15 watt for 1.5 sq. in. of sensitized surface. The bridge is rated as possessing a high ratio of dark resistance to resistance when subjected to an illumination of 10-ft. candles, and is practically independent of voltage.

Trade Literature

Transformers.—Bulletin 170, 64 pp. Describes Wagner power transformers. Wagner Electric Corporation, 6400 Plymouth Street, St. Louis.

Safety Switches.—Catalog 100-A. Describes Wadsworth safety switches and distribution panels. Wadsworth Electric & Manufacturing Company, Covington, Ky.

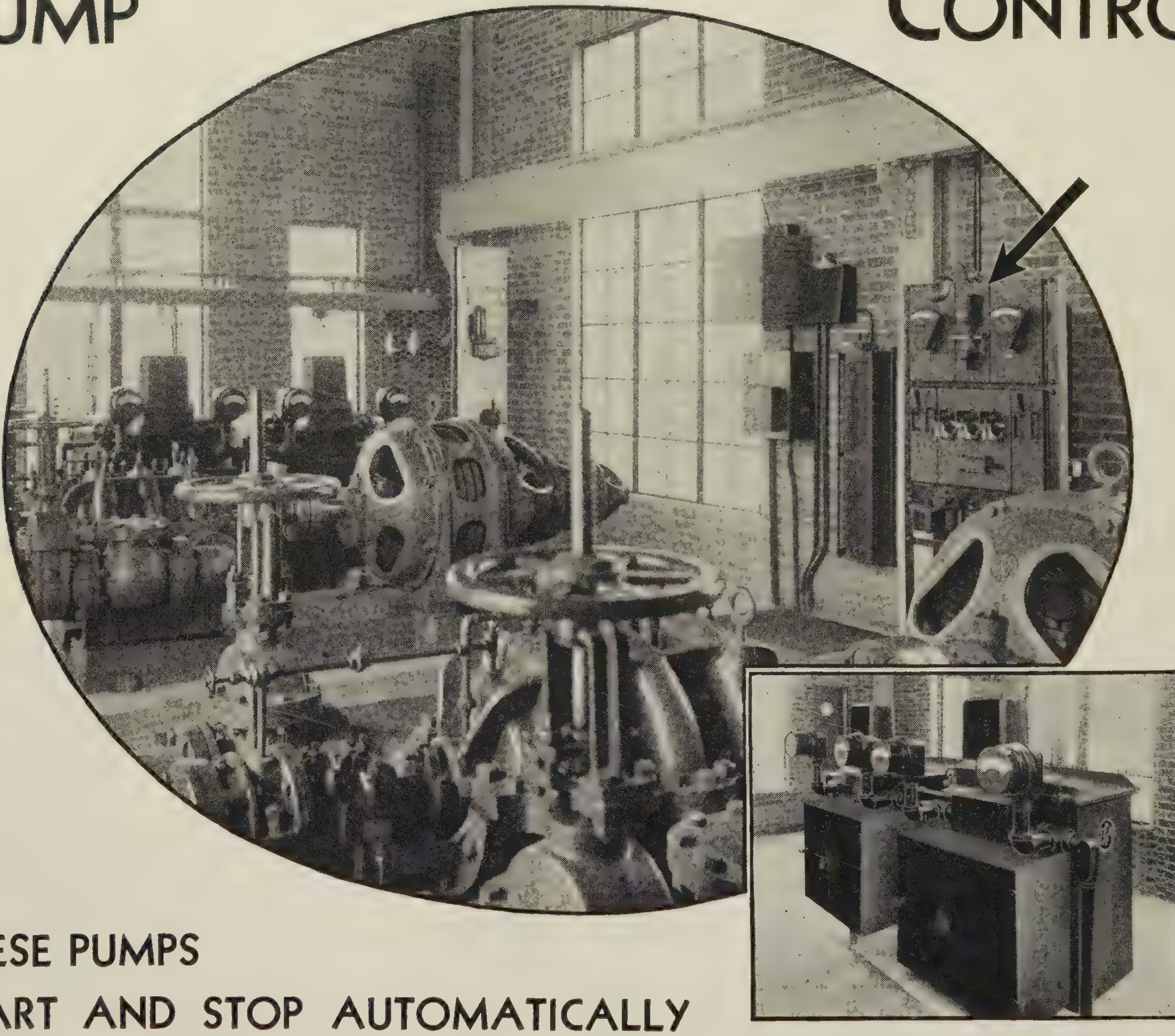
Transformers.—Bulletin 3006, 8 pp. Describes a new transformer for rural line service. Allis-Chalmers Manufacturing Company, Milwaukee.

Illumination. — Bulletin "Outdoor Sports Lighting," 16 pp. Includes specifications and photographs of typical installations. General Electric Company, Nela Park, Cleveland.

Motors.—Bulletin 520, 20 pp. Describes Ideal synchronous motors, 1 to 3,000 horsepower. Illustrations, application data and dimension charts are given covering the Ideal flywheel type synchronous motor (patented) and six other standard types of synchronous motors. A rather unusual method of giving dimensions is used whereby the approximate dimensions of any of the various types of motors for any horsepower and speed rating may be obtained. The Ideal Electric & Manufacturing Company, Mansfield, O.

Resistors.—Bulletin 19, 2 pp. Describes "Ribflex" vitreous enameled resistors. These resistance units consist of a metal alloy resistance ribbon, reflexed, wound on edge on a ceramic tube and banded at each end with heavy duty terminals. The entire unit is then covered with a fired-on vitreous enamel. The advantages claimed for this type of construction over any other form of tube resistor include—greater area for heat dissipation due to flat reflexed form of resistor element, wound on edge; high wattage for continuous duty; higher wattage for intermittent duty; easily assembled in associated apparatus due to individual units being available in low values of resistance; rugged terminals fitted with screws and nuts permit mounting by the terminals; classified as bare resistor under NEMA and Underwriters' rules. Ward Leonard Electric Company, Mount Vernon, N. Y.

EC&M AUTOMATIC PUMP CONTROL



THESE PUMPS START AND STOP AUTOMATICALLY

First, one pumping-unit is started up, then if the pressure continues to fall, the second pump is cut in, each unit being controlled automatically by the EC&M Altitude Regulator Panel shown at the right. Provision is also made for manual operation through push button control for test purposes independent of the Altitude Regulators.

What is your problem? EC&M Automatic Pump Control has benn applied successfully to many hundreds of installations. Some work underground in mines, others in municipal plants like the above, and still others in railroad wayside stations, petroleum pipe lines, etc. Full information is given in Bulletin 1100-J. Write for a copy.

THESE COMPLETELY ENCLOSED OIL-IMMERSED STARTERS OFFER THE UTMOST IN SAFE, DEPENDABLE OPERATION: Being oil-immersed, they are always well lubricated — always protected against moisture. The completely wired, totally enclosed feature makes them easy to install—you need only set them on the floor and connect the line and motor wires to the terminals. Since all live parts are enclosed, they are also shock-proof. Ask about them.

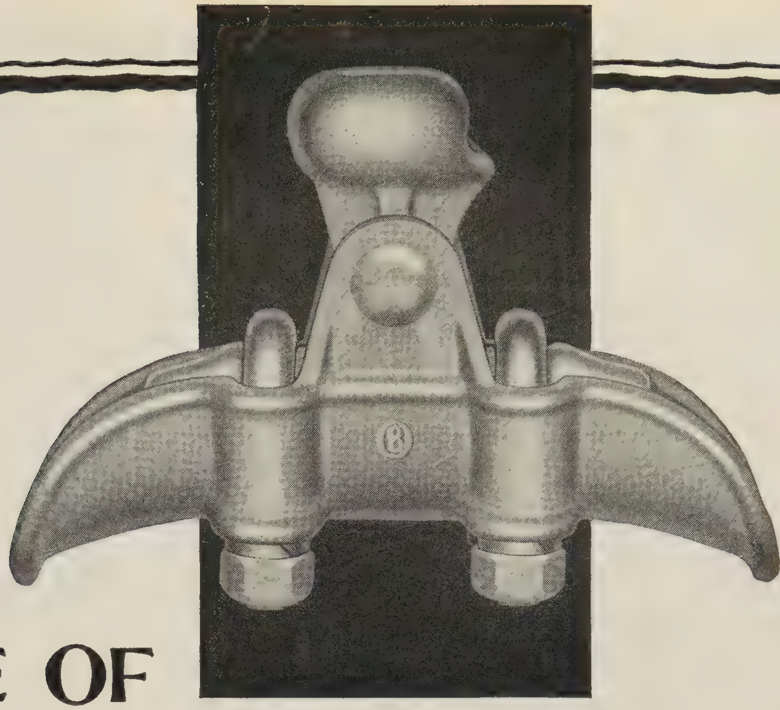
THE ELECTRIC CONTROLLER & MFG. CO.

CLEVELAND, OHIO

NEW YORK-50 CHURCH ST.
CHICAGO-CONWAY BLDG.
DETROIT-DIME BANK BLDG.
BIRMINGHAM-BROWN-MARX BLDG.
CINCINNATI-1ST NATIONAL BANK BLDG.
ST. LOUIS-6926 MARQUETTE AVE.

LOS ANGELES-912 E. THIRD ST.
HOUSTON-P.O. BOX 4182
TORONTO-REFORD BLDG.

PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
MONTREAL-CASTLE BLDG.
TULSA-COMMERCIAL BLDG.
SEATTLE-2207-1ST AVE. SO.



A NEW LINE OF *Light-Weight* O-B SUSPENSION CLAMPS

GREATER economy in construction costs of transmission lines, and standardization of materials were among the most important subjects discussed at the recent N.E.L.A. Convention. Obviously, the adoption of such principles and practices will result in worth-while economies, for "custom-made" materials cannot be manufactured or obtained within the price limits made possible by standardized lines.

Coincident to this new viewpoint in the industry, there is announced a new, complete line of *light-weight* O-B suspension clamps, for all sizes of conductor from 2-0 to 795,000 C.M. While suited to A.C.S.R. conductor with armor rods, this line will serve equally well with other types of conductors of comparable size requirements. These new clamps while conforming in general design to the type of clamp first introduced by O-B, are distinctly different, and embody design features made necessary by the character of the service they must perform.

A shorter, smooth conductor seat, of proper curvature to best serve the cable; much lighter weight; "J" bolts or "U" bolts depending upon the grip required; and general compactness are characteristics of these clamps.

These new clamps are of O-B Flecto iron, hot-dip galvanized. By the use of the Flecto process, thinner sections of metal have been employed without danger of internal weakness or embrittlement. Adequate strength is provided, and the corrosion-resisting characteristics of O-B Flecto iron assure a service life for these new clamps which will equal or exceed the life of the other materials employed in transmission line construction.

Complete information on this new standard line of O-B *light-weight* suspension clamps is in the hands of all O-B representatives, or can be obtained by addressing—

SEND FOR COMPLETE INFORMATION

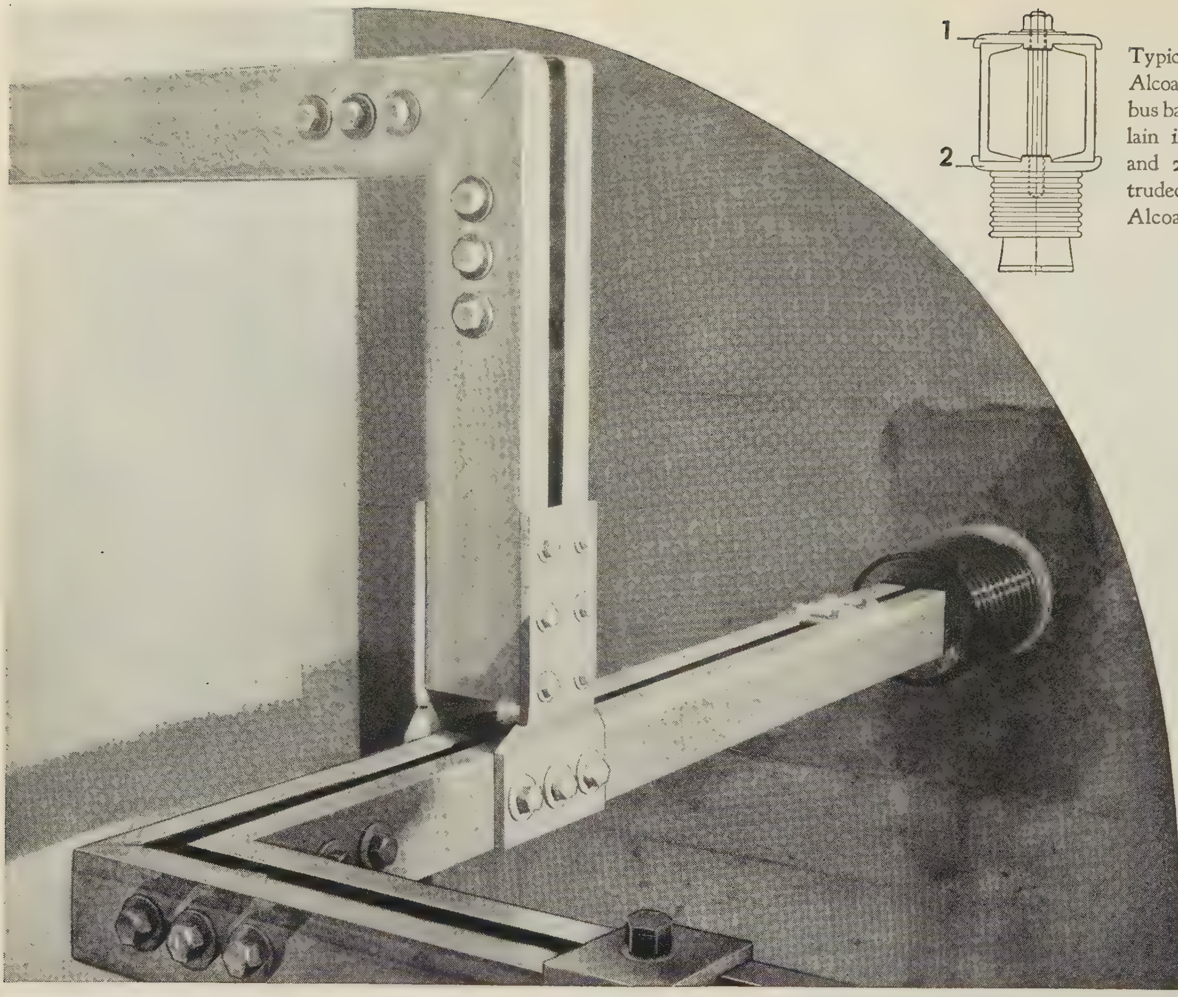
1437-H

OHIO BRASS COMPANY

Mansfield, Ohio, U. S. A.

Canadian Ohio Brass Co. Limited — Niagara Falls, Ontario, Canada

New York • Philadelphia • Boston • Pittsburgh • Chicago • Cleveland • St. Louis • Atlanta • Dallas • Los Angeles • San Francisco • Seattle



Typical arrangement of Alcoa Aluminum channel bus bar mounted on porcelain insulator. Figures 1 and 2, clamps from extruded section of strong Alcoa Aluminum alloy.

Aluminum Channel Bus Bar is more rigid and requires fewer supports

This 440 volt A.C. bus at the Chute à Caron Hydro-Electric Development shows the construction possibilities of Alcoa Aluminum channel bus bar. This new bus bar shape is available in long lengths, requires few supports and makes erection rapid and easy. In time and weight-saving alone Aluminum channel bus bar proves its value.

Alcoa Aluminum channel bus bar provides more efficient metal distribution for heavy A.C. currents than any other type of bar. Erected flange to flange to form a hollow square, it assures ample internal ventilation. For currents over 3,000 amperes channel bus bar construction occupies less space than assemblies generally used.

This bus bar is available in long lengths, 45 feet or more, and in standard sizes up to 8 inches. Compared with flat bar, Aluminum channel bus bar provides greater rigidity with equal ease of assembly. Compared with tubular bar, it has lower reactance and requires less complicated fittings.

Let us supply you with the electrical characteristics of Alcoa Aluminum channel bus bar; its weight and other technical data. ALUMINUM COMPANY *of* AMERICA; 2448 Oliver Building, PITTSBURGH, PENNA.

ALCOA ALUMINUM

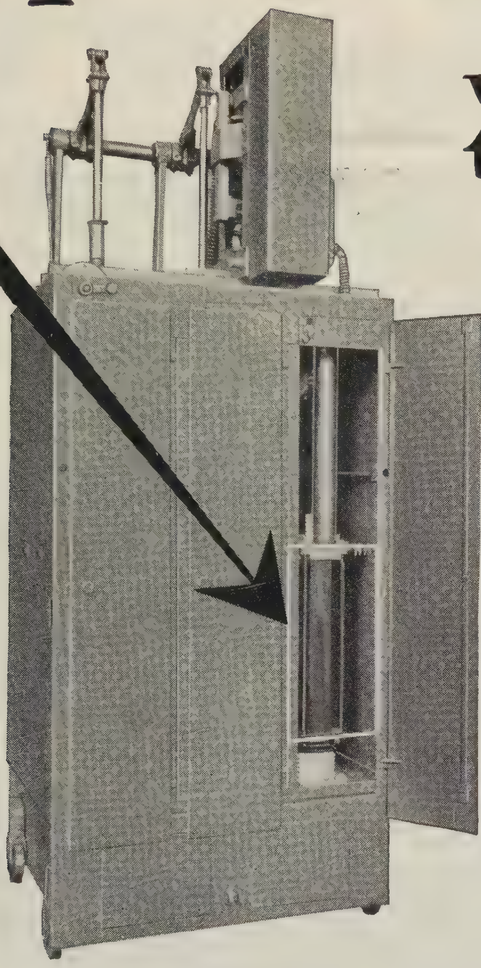
REG. U.S. PAT. OFF.

BUS BARS MADE OF

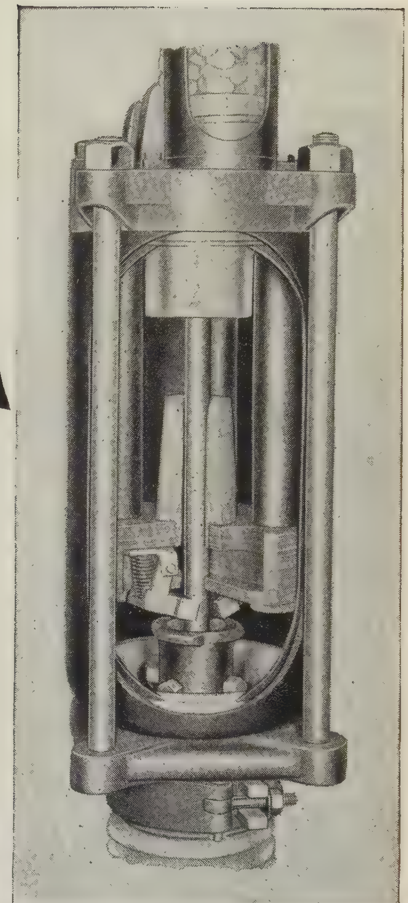
ALCOA ALUMINUM

Replace

this



with this



and let the oil-blast baffle increase the speed and interrupting ability of your FH breakers

IN most FH breakers already in service, you need only replace the baffle with the new oil-blast baffle to obtain greatly increased interrupting ability. This change, which can be made quickly, easily, and economically, will provide the advantages of oil-blast operation with all its benefits.

This new oil-blast baffle does more than materially increase your breakers' interrupting ability. It reduces maintenance expense by minimizing burning of arcing contacts and thus adding to their life; by decreasing the burning of insulated parts; and by slowing the rate of oil deterioration.

This principle of operation — proved beyond question — has other advantages, apparent upon closer study. In the interest of economic maintenance of your switching equipment and system, examine a copy of GEA-1449, which the nearest G-E office will be glad to furnish upon request. General Electric Company, Schenectady, New York.

JOIN US IN THE GENERAL ELECTRIC PROGRAM, BROADCAST EVERY SATURDAY EVENING ON A NATION-WIDE N.B.C. NETWORK

470-24

GENERAL GE ELECTRIC

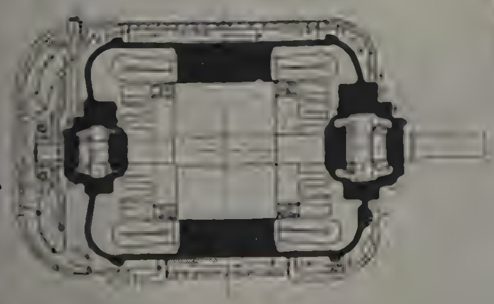
SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES

Protection costs less than maintenance

Wagner type CP motors are totally enclosed against the entrance of dust, fumes and moisture. Hence, there is practically no maintenance—no frequent shut-downs to remove abrasive and clogging dust; no replacement of corroded and short-circuited windings; no special housing for protection against corrosive gases, steam and moisture. » » Each CP motor is a one-time investment, with no subsequent upkeep other than that of periodic greasing. » » More and more plant managers are realizing that motor protection costs less than motor maintenance—that no open type motors should be expected to operate where dust, fumes, gases and moisture prevail. » » If such conditions obtain in your plant, you will find Wagner bulletin 151

At Right—Wagner Bulletin 151 illustrating and describing Wagner totally-enclosed fan-cooled motors.

Below—Cross-section view of Wagner totally-enclosed fan-cooled motor.



helpful. Let us send you a copy of Bulletin 151 without in any way obligating you. Just sign and mail the coupon.

WAGNER ELECTRIC CORPORATION,
6400 Plymouth Ave., St. Louis, Mo.

Please send me your Bulletin 151 on totally enclosed fan-cooled motors.

Name and Position

Company

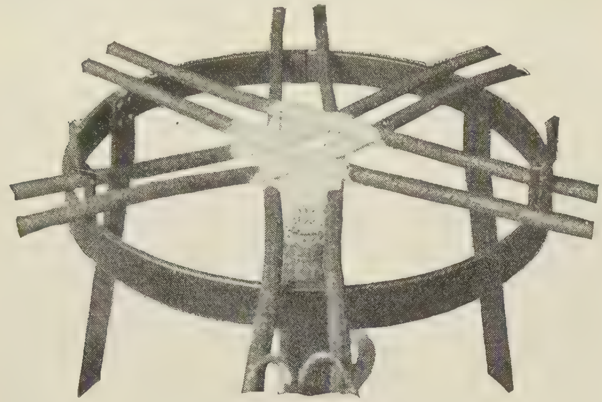
Address

Wagner Electric Corporation
6400 Plymouth Avenue, Saint Louis, U. S. A.

MOTORS TRANSFORMERS FANS
LOCKHEED HYDRAULIC BRAKES

L331-5XA


"hold everything Charlie I-T-E is coming out with three (3) revolutionary circuit breaker developments"
?



Would your Wiring Stand Treatment like this?

"OF course not," you say, "it wouldn't have to." And you would be right to a certain extent.

But wiring of certain types such as that in boiler rooms, chemical plants, oil refineries and around blast furnaces to mention a few places, must be exposed to deteriorating conditions during normal service.

It is just such conditions as these—heat, moisture, oil, grease and fumes—that deteriorate ordinary insulated wires and cause failure. Under such conditions a wire with insulation that is not affected by the prevailing conditions should be used. ROCKBESTOS is that type of wire.

The illustration shows the most severe part of a test run on ROCKBESTOS wire at the recent N. E. L. A. convention at Atlantic City. The wire, carrying current, was attacked by oil, grease, fumes and fire and was also immersed in water. Its resistivity to these various deteriorating conditions is best indicated by its performance under exposure to the full flame of a large Bunsen burner.

The dielectric strength of the new wire was 15,000 volts average. At the close of the convention, after more than 60 hours of burning, with the insulation red hot, the burned sections were removed, tested and found to still have an average dielectric strength of 3,530 volts!

Glad to send you the complete story of this test, also samples and data. Mention if you are interested in wire for a specific purpose or conditions. Use the handy coupon and send it now.

ROCKBESTOS PRODUCTS CORPORATION
390 NICOLL STREET   NEW HAVEN, CONN.

ROCKBESTOS—*the wire with permanent insulation*

ROCKBESTOS PRODUCTS CORP., 390 Nicoll St., New Haven

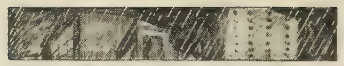
Please tell me more about non-deteriorating ROCKBESTOS wire.

Name...

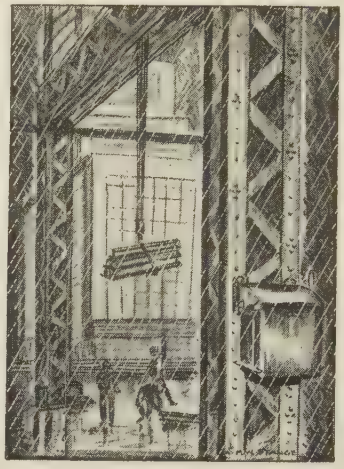
Title...

Company...

Address...



NO SHELTER IS NEEDED



for Rowan Oil Immersed Control Equipment

ROWAN CONTROL is completely oil immersed—and that means high interrupting capacity—remarkably long life because corrosion is practically eliminated and constant lubrication is provided for all moving parts—and safety, since all arcs are ruptured below the surface of the oil which eliminates the danger of spreading the flames to combustible gases in the surrounding atmosphere.

Send today for a complete set of bulletins describing each unit of Rowan Oil Immersed Control.

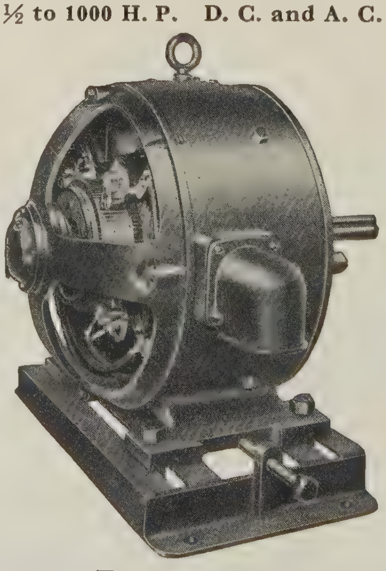
ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

The Pioneer Manufacturer
— of —

Interpole & Ball Bearing Motors

½ to 1000 H. P.   D. C. and A. C.



Type "S" Ball Bearing Motor

ELECTRO DYNAMIC COMPANY

Manufacturers of Ball Bearing Motors Since 1904

BAYONNE, N. J.

Sales Offices in Principal Cities

"Quality for Half a Century"

Index to Advertised Products

AIR COMPRESSORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Western Electric Co., All Principal Cities

AMMETER COMPENSATING COILS
Minerallac Electric Co., Chicago

AMMETER, VOLTMETERS
(See INSTRUMENTS, ELECTRICAL)

ANCHORS, GUY
Copperweld Steel Co., Glassport, Pa.
Kearney Corp., Jas. R., St. Louis

BATTERY CHARGING APPARATUS
Electric Products Co., Cleveland
Electric Specialty Co., Stamford, Conn.
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Ward Leonard Electric Co.,Mt. Vernon, N.Y.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BOXES, FUSE
Bull Dog Electric Products Co., Detroit
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BOXES, JUNCTION
G & W Elec. Specialty Co., Chicago
General Cable Corporation, New York
Metropolitan Device Corp., Brooklyn, N. Y.

BRUSHES, COMMUTATOR
Carbon
Morganite Brush Co., Inc., L. I. City, N. Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Copper Graphite
Morganite Brush Co., Inc., L. I. City, N. Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BUS BARS, ALUMINUM
Aluminum Co. of America, Pittsburgh

BUS BAR FITTINGS
Burndy Engineering Co., Inc., New York
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BUSHINGS, PORCELAIN
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CABLE ACCESSORIES
Dossert & Co., New York
G & W Electric Specialty Co., Chicago
General Electric Co., Schenectady
Minerallac Electric Co., Chicago
Western Electric Co., All Principal Cities

CABLE RACKS
Metropolitan Device Corp., Brooklyn, N. Y.

CABLES
SEE WIRES AND CABLES

CABLEWAYS
American Steel & Wire Co., Chicago
Roebling's Sons Co., John A., Trenton, N. J.

CASTINGS, ALUMINUM
Aluminum Co. of America, Pittsburgh

CIRCUIT BREAKERS
Air—Enclosed
Condit Elec. Mfg. Corp., Boston
I-T-E Circuit Breaker Co., The, Philadelphia
Roller-Smith Co., New York
Ward Leonard Electric Co.,Mt. Vernon, N. Y.
Western Electric Co., All Principal Cities
Oil
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CLAMPS, GUY & CABLE
Burndy Engineering Co., Inc., New York
Kearney Corp., Jas. R., St. Louis
Malleable Iron Fittings Co., Branford, Conn.
Railway Ind. & Engg. Co., Greensburg, Pa.

COILS, CHOKE
American Transformer Co., Newark, N. J.
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COILS, MAGNET
General Cable Corporation, New York
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COMMUTATOR SEGMENTS AND RINGS
Mica Insulator Co., New York

CONDENSERS, RADIO
General Radio Co., Cambridge, Mass.

CONDENSERS, STEAM
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONDUIT, UNDERGROUND FIBRE
Western Electric Co., All Principal Cities

CONNECTORS SOLDERLESS
Dossert & Co., New York
Kearney Corp., Jas. R., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONNECTORS AND TERMINALS
Burndy Engineering Co., Inc., New York
Dossert & Co., New York
G & W Electric Specialty Co., Chicago
Railway & Ind. Engg. Co., Greensburg, Pa.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONTACTS, TUNGSTEN
General Electric Co., Schenectady

CONTROL SYSTEMS
Ward Leonard Electric Co., Mt. Vernon, N. Y.

CONTROLLERS
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Rowan Controller Co., Baltimore, Md.
Ward Leonard Electric Co., Mt. Vernon, N. Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONVERTERS—SYNCHRONOUS
Allis-Chalmers Mfg. Co., Milwaukee
Electric Specialty Co., Stamford, Conn.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COPPER CLAD WIRE
American Steel & Wire Co., Chicago
Western Electric Co., All Principal Cities

COPPERWELD WIRE
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York

CUT-OUTS
Bull Dog Electric Products Co., Detroit
Condit Electrical Mfg. Corp., S. Boston
General Electric Co., Schenectady
G & W Electric Specialty Co., Chicago
Kearney Corp., Jas. R., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

DIMMERS, THEATRE
Ward Leonard Electric Co., Mt. Vernon, N. Y.

DIVERTER POLE GENERATORS
Electric Products Co., Cleveland, O.

DYNAMOS
(See GENERATORS AND MOTORS)

DYNAMOTORS
Electric Products Co., Cleveland, O.
Electric Specialty Co., Stamford, Conn.

ELECTRIFICATION SUPPLIES, STEAM ROAD
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, Ohio
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

ENGINEERS, CONSULTING AND CONTRACTING
(See PROFESSIONAL ENGINEERING DIRECTORY)

ENGINES
Gas & Gasoline
Allis-Chalmers Mfg. Co., Milwaukee
Oil
Allis-Chalmers Mfg. Co., Milwaukee
Steam
Allis-Chalmers Mfg. Co., Milwaukee

FANS, MOTOR
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FLOW METERS
General Electric Co., Schenectady

FURNACES, ELECTRIC
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FUSES
Enclosed Refillable
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Enclosed Non-Refillable
General Electric Co., Schenectady
Open Link
General Electric Co., Schenectady
Metropolitan Device Corp., Brooklyn, N. Y.
High-Tension
Metropolitan Device Corp., Brooklyn, N. Y.
Railway & Ind. Engg. Co., Greensburg, Pa.

FUSE MOUNTINGS
Railway & Ind. Engg. Co., Greensburg, Pa.

FUSE PULLERS
Kearney Corp., Jas. R., St. Louis

GEARS, FIBRE
General Electric Co., Schenectady

GENERATORS AND MOTORS
Allis-Chalmers Mfg. Co., Milwaukee
Electric Products Co., Cleveland, O.
Electric Specialty Co., Stamford, Conn.
Electro-Dynamic Co., Bayonne, N. J.
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

GENERATING STATION EQUIPMENT
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

GROUND RODS
Copperweld Steel Co., Glassport, Pa.
Metropolitan Device Corp., Brooklyn, N. Y.

HARDWARE, POLE LINE AND INSULATOR
General Electric Co., Bridgeport, Conn.
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

HEADLIGHTS
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Strowger Railway Communication Equipment

Strowger Power Supervisor's Board

Strowger Tele-Chec System

Strowger Police Alarm System

Strowger Fire Alarm Systems

Strowger Dial Telephone Systems

BACK OF THIS CHANGE to DIAL TELEPHONES-

IN a few years the old-fashioned telephone—the kind without a dial—will be a thing of the past. Already over ten million dial telephones are in service in various parts of the world. More than three-quarters of them depend for their successful operation on Strowger relays and remote-control switches.

To modern business and industry this fact is important, because those very qualities which have led to the world-wide adoption of Strowger Dial Telephone Equipment have also created a demand for other Strowger products in the broader fields of communication, signaling and remote-control.

Strowger P-A-X, for example—the accepted private telephone system—is based on Strowger relays and remote-control switches. These same essential elements are used in Strowger Police and Fire Alarm Systems, in the Strowger Power Supervisor's Board, and in Strowger Railway Communication Equipment. They are also important elements in the operation of elevators, traffic signal systems and power substations. They help to package food—to keep theatres filled to capacity—to centralize accounting in mercantile establishments—to set up stock market quotations. There is literally no end to the application of these Strowger devices.

If your problem—no matter if it relates to the design of your products or to your manufacturing processes—involves communication, signaling or remote-control over wires, we suggest that you consult the Strowger staff. They will be glad to analyze your needs and submit suggestions, entirely without cost or obligation to you. Or, if you would like information on any specific Strowger product, use the coupon below.

Besides Strowger Dial Telephone Equipment—the accepted dial telephone system for private organizations and public systems alike—Automatic Electric Inc. offers the following line of perfected communication systems and equipment. For information on any or all of them, use the coupon.

- Railway Communication and Signal Equipment
- Industrial Fire Alarm Systems
- Code Signal Systems (Audible and Visual)
- Supervisor's Boards for Power Networks
- Municipal Fire Alarm Systems
- Police Recall and Alarm Systems
- Theatre Telephone and Signal Systems
- Portable Telephones and Line Test Sets
- Watchmen's Supervisory Systems
- Remote-Control Time Recorders
- Relays, Remote-Control Switches and Signal Accessories

Engineered, Designed and Manufactured by

Automatic Electric Inc.

Factory and General Offices:

1031 West Van Buren Street, Chicago, U. S. A.

SALES AND SERVICE OFFICES:

Atlanta	Boston	Cincinnati	Cleveland
Detroit	Kansas City	Los Angeles	New York
Philadelphia	Pittsburgh	St. Paul	Washington

ATTACH TO YOUR LETTERHEAD AND MAIL TO

AUTOMATIC ELECTRIC INC., 1031 W. Van Buren St., Chicago

Please send us bulletins on:

- ☐ Private Dial Telephone Systems
- ☐ Relays and Remote-Control Switches
- ☐ Fire Alarm Systems
- ☐ Railway Communication Equipment
- ☐ ....

Name ....

Position ....

Index to Advertised Products—*Continued*

Index to Advertised Products—*Continued*

SUB-STATIONS
American Bridge Co., New York
General Electric Co., Schenectady
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SWITCHBOARDS
Allis-Chalmers Mfg. Co., Milwaukee
Bull Dog Electric Products Co., Detroit
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Metropolitan Device Corp., Brooklyn, N. Y.
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SWITCHES
Automatic Time
General Electric Co., Schenectady
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Disconnecting
Bull Dog Electric Products Co., Detroit
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Fuse
Bull Dog Electric Products Co., Detroit
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.
Knife
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Magnetic
Electric Controller & Mfg. Co., Cleveland
Ward Leonard Electric Co., Mt. Vernon, N. Y.
Oil
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Remote Control
Automatic Electric, Inc., Chicago
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Rowan Controller Co., Baltimore, Md.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TELEPHONE CONNECTORS
Kearney Corp., Jas. R., St. Louis

TELEPHONE & SIGNALING SYSTEMS
Automatic Electric, Inc., Chicago

TESTING SETS, HIGH VOLTAGE
American Transformer Co., Newark, N. J.
General Electric Co., Schenectady

TOWERS, TRANSMISSION
American Bridge Co., New York

TRANSFORMERS
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Chicago Transformer Corp., Chicago
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis
Sangamo Electric Company, Springfield, Ill.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Factory
American Transformer Co., Newark, N. J.
Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis, Mo.
Wagner Electric Corp., St. Louis
Furnace
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Moloney Electric Co., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TRANSFORMERS—*Continued*
Metering
American Transformer Co., Newark, N. J.
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Roller-Smith Co., New York
Sangamo Electric Company, Springfield, Ill.
Weston Elec. Inst. Corp., Newark, N. J.
Radio
American Transformer Co., Newark, N. J.
Chicago Transformer Corp., Chicago
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Sangamo Electric Company, Springfield, Ill.
Street Lighting
Kuhlman Electric Co., Bay City, Mich.

TROLLEY LINE MATERIALS
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBINE GENERATORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBINES, HYDRAULIC
Allis-Chalmers Mfg. Co., Milwaukee

TURBINES, STEAM
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBO-GENERATORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

VALVES, BRASS
Gas, Water, Steam
Ohio Brass Co., Mansfield, O.

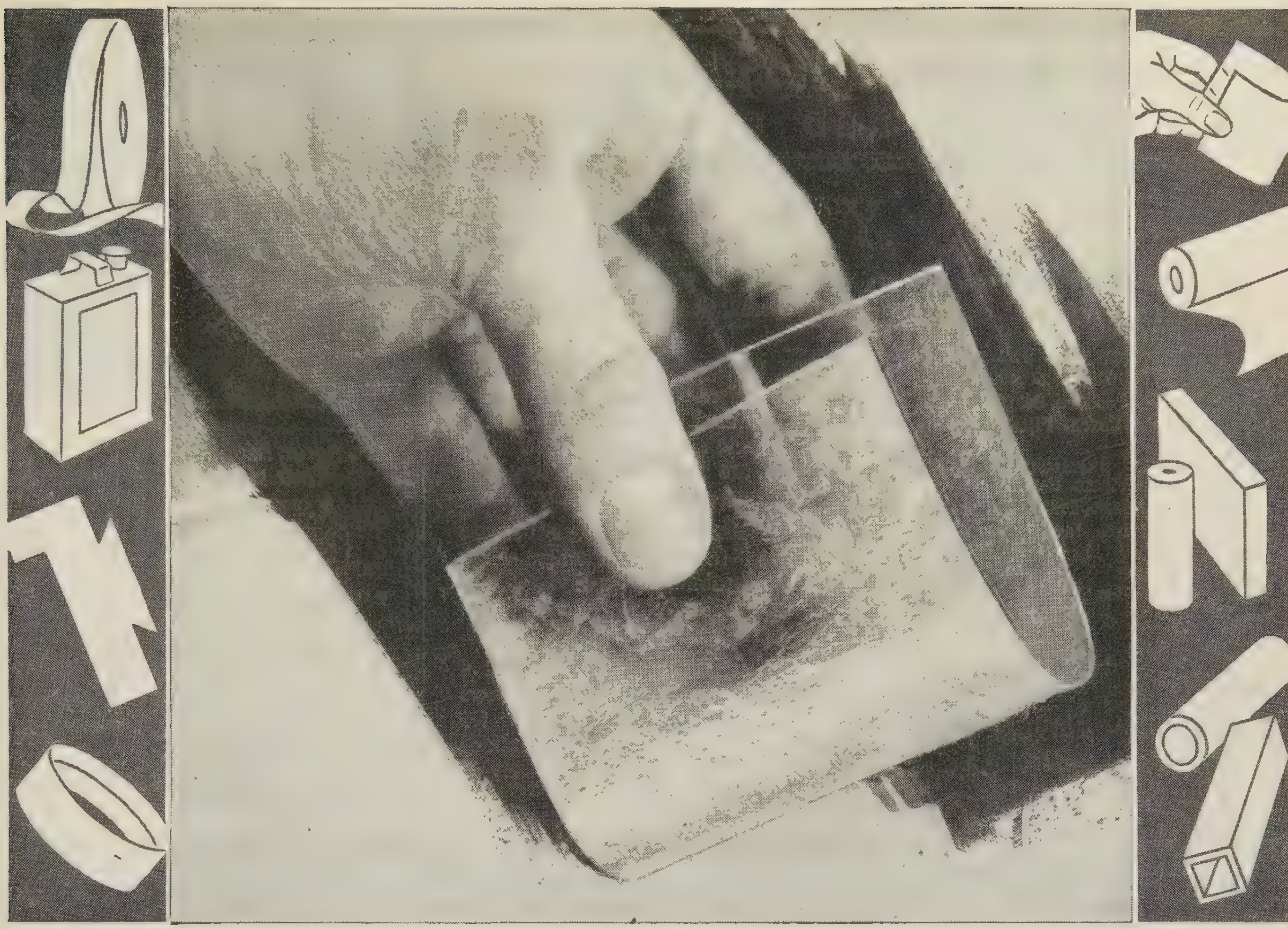
VARNISHES, INSULATING
General Electric Co., Bridgeport, Conn.
Irvington Varnish & Insulator Co., Irvington N. J.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WELDING MACHINES, ELECTRIC
American Transformer Co., Newark, N. J.
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WELDING WIRES & RODS
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
Ohio Brass Co., Mansfield, O.

WIRES AND CABLES
Aluminum and A. C. S. R.
Aluminum Co. of America, Pittsburgh
Armored Cable
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities
Asbestos Covered
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Rockbestos Products Corp., New Haven, Conn.
Asbestos, Varnished Cambric
Rockbestos Products Corp., New Haven, Conn.
Automotive
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

WIRES AND CABLES—*Continued*
Bare Copper
American Steel & Wire Co., Chicago
General Cable Corporation, New York
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities
Copper Clad
American Steel & Wire Co., Chicago
Western Electric Co., All Principal Cities
Copperweld
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
Flexible Cord
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Flexible Cord, (Heater) Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
Heavy Duty Cord
American Steel & Wire Co., Chicago
General Cable Corporation, New York
Okonite Company, The, Passaic, N. J.
Simplex Wire & Cable Co., Boston
Fuse
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Lead Covered (Paper and Varnished Cambric Insulated)
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Okonite-Callender Cable Co., The, Inc., Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities
Leads, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
Magnet
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities
Magnet, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
Rubber Insulated
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities
Switchboard, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
Tree Wire
General Cable Corporation, New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Trolley
American Steel & Wire Co., Chicago
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities
Weatherproof
American Steel & Wire Co., Chicago
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities



ALPHABETICAL LIST OF ADVERTISERS

TREATING the soil in order to obtain satisfactory ground resistance can be done most satisfactorily by this latest Murray development. After the rod has been installed merely pour the treating solution into the non-corrosive—long life copper tube.

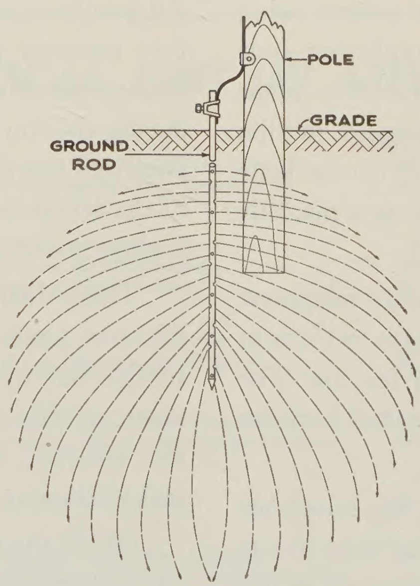
It is no longer necessary to treat the ground external to the rod.

ELIMINATE guesswork—keep your grounds at the resistance best for your operating conditions.

In booklet we have compiled a quantity of interesting data which is yours for the asking.

Murray Copper Tube Grounds are in wide use. Make a test installation,—that will convince you.

MURRAY COPPER-TUBE GROUND ROD



REGULATES GROUND RESISTANCE

METROPOLITAN DEVICE CORPORATION

1250 Atlantic Ave., Brooklyn, N. Y.

Use Coupon for Booklet

Metropolitan Device Corporation
1250 Atlantic Ave., Brooklyn, N. Y.

You may send me 8-page booklet on Murray Copper Tube Grounds and chart of soil treatment.

Name ....
Title ....
Company ....
Address ....